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BRITISH JOURNAL OF INDUSTRIAL MEDICINE

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Brit. J. industr. Med., 1948, **5**, 107.

THE DISABLED PERSONS (EMPLOYMENT) ACT, 1944: SOME MEDICAL IMPLICATIONS*

BY

W. TAYLOR

From the Ministry of Labour and National Service, London

(RECEIVED FOR PUBLICATION, FEBRUARY 19, 1948)

Historical Survey

It is only in very recent times that the problem of disablement has come to be accepted as a problem of employment, and that its range and complexity have been generally recognized. The Disabled Persons (Employment) Act dates from 1944, and the Ministry of Labour has been in the field of resettlement and rehabilitation only since 1941. It is equally true that industrial medicine is of comparatively recent growth. It might be worth while to glance at the reasons why that has been so, because I think in this case history does illumine the present.

It would probably be true of most of us that when we come to the problem of disablement for the first time we think of it in terms of a few unfortunate people who are only fit for specialized crafts such as basket-making and flower-making. Broadly, that was the only idea which prevailed up to the first world war. Between the wars a considerable development took place, especially on the medical side. Two factors were then operating to bring about a change. One was the fact of the war disabled which was brought home to all of us in that generation. The personal tragedy of blindness or amputation in an otherwise healthy young man appealed to public imagination in a way that the chronic case had never done, and one result of public concern for the disabled ex-serviceman was to stimulate progress in the treatment, both medical and social, of disablement generally.

The other factor was the growth of social legislation and in particular of workmen's compensation. That laid on industry the responsibility for its own casualties. The injured workman became a charge on production, and his early return to work therefore became important. It paid to restore him to full health at the earliest possible moment. One result of the measures that were taken originally for that purpose was to diminish the number of industrial casualties who were allowed to become permanently disabled.

But all that was still largely in the medical and social field. The recognition of the employment implications came in quite another way and only with the recent war. In 1941, to be exact, when the problem of finding manpower simultaneously for the Armed Forces and for industry became acute, we were obliged to look at the large number of men and women who might have substantial handicaps but nevertheless represented a potential labour force. So we launched a scheme to bring the disabled into the war effort. There may have been imagination in that, but there was primarily nothing of sentiment. And in operating that scheme we discovered, of course, a number of important things.

We discovered that the great majority of the disabled were capable, with proper selection of their job, of taking their place in ordinary employment alongside the able-bodied. We discovered that a great many of them could be placed in work without any training other than that on the job. Some might have to have the job broken down for them but, broadly speaking, given the selection of the worker for the job and job for the worker, the problem proved to be nothing like so formidable as had been thought. What is more, we found that, of those not able to take their place in ordinary competitive industry, most were capable of rendering some useful service under sheltered conditions and thus of contributing to national production.

Some Misapprehensions

It was in that way that the Ministry of Labour came into the field, and it was to conserve those lessons that the Disabled Persons (Employment) Act was framed. I emphasize this point and I have gone into the history in some detail in order to remove a number of misapprehensions.

One misapprehension is that the Ministry of Labour has somehow illicitly invaded the medical

* Statement made in opening a discussion at a meeting of the Birmingham Group of the Association of Industrial Medical Officers on Dec. 16, 1947, with Dr. Donald Stewart in the Chair.

field and is trying to do somebody else's job for them. Nothing is further from the truth. We are in this field for the reasons I have stated, with a limited interest and a specified commission, and we are much too busy with the parts of the job that are our proper responsibility to want to filch anyone else's job or infringe on their responsibility.

Another misapprehension is just the opposite. It is that because the Ministry of Labour is in the field then its contribution is the solution to everything. The Ministry of Labour has a contribution to make and it will gladly make it; but it is only one contribution among others. Advances in the employment aspects of the problem must be accompanied by similar advances in other fields, in medicine, in the hospital services and in the field of social legislation.

Still another misapprehension is to overlook the fact that the Ministry of Labour is in this field with a specifically industrial function, and to imagine that it ought necessarily to employ the same kind of person that is employed in hospital services on very much the same kind of work. Some people talk, for example, as if a Disablement Resettlement Officer (D.R.O.) ought to look like an unqualified medical practitioner and talk like a hospital almoner. The D.R.O. is there with quite a different function. He is there for his industrial knowledge because industry is a world of its own with its own technicalities and its own language, just as medicine is. A man is not a worse D.R.O. because he drops his "h's" or has not been through a university department of social science. The essential point is to see clearly and in their right perspective the distinctive contributions that each of us can make. Only by each contribution being fully made in its own field can the general advance we all want to see be achieved.

The Ministry of Labour's Commission

Let me now say something of what the Ministry of Labour's specific commission is. We have very definite statutory functions laid upon us by the Act.

1. We must maintain a register of persons who are handicapped by reason of their disability from getting or keeping work. That is the "Disabled Register."

2. We must from time to time prescribe a percentage proportion of disabled persons which all substantial employers of labour are required to employ. That is the "quota."

3. We must provide industrial rehabilitation and vocational training where these are required.

4. We must provide special facilities in the way of sheltered employment for those who are not able to work under ordinary conditions.

5. We must at all times use our best endeavours to find suitable work for the disabled by the best possible selection and placement methods. That is "selective placing."

Those are five apparently simple practical objectives, and you can understand why to the plain man they may seem a perfectly straightforward job requiring only common sense and human sympathy. But they are a great deal more complex than they look, and it is with these complications and elaborations that we are now concerned. Here are some of them.

Form D.P.1.—The form D.P.1 is the form on which the lay D.R.O. gets from the doctor medical evidence about the disability. This raises straight away the question of what medical evidence you need as a guide to placing a man in work. When we started we had a fairly simple form called R.D.1. That left the hospital or the doctor free to report the disability in their own terms and you can guess what happened then. The medical reports were expressed in medical terms which were difficult for a lay staff to understand. Similarly our lay staff, when they discussed cases with the medical man, were apt to refer to them in their technical terms (occupational terms, and so on) which the medical man did not always understand. It was like the tower of Babel: neither understood the other's language.

We therefore set up a small informal committee to solve the problem. It consisted of Mr. H. E. Griffiths, the London surgeon; Dr. E. L. Middleton, Medical Inspector of Factories; and Dr. R. H. Fleming, Director of Medical Services, Ministry of Pensions: and we associated with them some of our own experts in occupational classification who had drawn up the Schedule of Reserved Occupations. That small committee of doctors and industrial experts produced between them roughly the D.P.1 in its present form. The basic assumption underlying it is that what the lay placing officer needs is not the technicalities of diagnosis expressed in medical terms but the effects of the disability on functional capacity. He wants to have the ability or disability assessed in working terms; to be told what the man can do and what he cannot do. This the form does in terms of walking, standing, sitting, pushing, pulling, working on heights, working underground and so on, to meet the common hazards that are to be found in industrial occupations.

Despite its distinguished medical parentage the form met with a very mixed reception and it has never been possible to get it adopted for general use in the medical profession. For administrative and technical reasons, hospitals feel unable to complete

it, and it is not used to any great extent by the general medical practitioner. Those who do use the form tell us that it is quite simple to complete once you have done a full examination and diagnosis. But I must confess it is a somewhat formidable document. Nevertheless I think it is a pity it is not more generally used, because without something of the kind the placing officer has to carry on with what information he gets in whatever form he happens to get it.

We had thought that, if the D.P.1 proved to be a solution to the problem of medical evidence, we would use it as a basis on which to build up a series of variants to fit different classes of disability. We have, for example, produced a variant of the form for use in tuberculosis cases. But we have not carried differentiation any further, because really the form in which we get the medical evidence is not the crucial point. The right solution for our problem will depend, not upon any exchange of documents between us and the medical profession, but on the general relationship that exists between the medical world and the D.R.O. service. We require closer and better co-operation than can be obtained from any form of report, however good or however detailed, and we are trying to get that better and closer co-operation by another route.

Medical Interviewing Committees.—We are proposing to set up special Medical Interviewing Committees based on hospitals, to which we can refer individual cases of difficulty for special advice in connexion with placement. The first of these committees in this Region has been appointed at Stoke-on-Trent. Each of these committees will consist of a medical man from the hospital, of registrar status as a minimum, and a doctor with industrial experience. They will be able to call in specialist consultants if necessary. They can consult hospitals, private practitioners, industrial medical officers, or anybody else who may at any time previously have examined the man, and they will examine the man themselves. Then the D.R.O., who will be in attendance, can discuss the case with them and put to them any point of difficulty which arises from his point of view.

It is proposed that the Medical Interviewing Committee should start off by using the form D.P.1, but experience may very well show that a better form can be devised, and if it does then we shall not only have got our basic paper work done but we shall also have forged a valuable working link between the medical and industrial sides. The Medical Interviewing Committees and the D.R.O. by working closely together on actual cases will come to understand each other's problems. And it really is vitally important that they should understand each other.

Links with Hospitals.—Our relationships in the Ministry with hospitals should be much closer than they are. The common explanation of why they are not as close as they might be is that our staff is not of the type who can meet doctors and almoners on equal terms. Well, suppose that is true. Where does it take us? Here is a tragic human problem—the problem of a sick man who has to find his way back to work. The key to his problem may lie partly in the medical field, but wherever the key lies it should be found. We owe it to the man himself, all of us, to put every bit of knowledge and effort at his disposal. Whether we are doctors, or D.R.O.'s, or almoners, or anybody else, every contribution that can be made to that man's problem should be made by all of us without prejudice and without standing upon the order of our going. What I would like to see is a perfectly normal two-way traffic between the hospitals and the D.R.O.'s, each relying on the other for what each can give, and neither expecting the other to be what they are not.

Industrial Rehabilitation.—The relationship between industrial rehabilitation and medical rehabilitation is a much-discussed question. The Act proceeds on the assumption that there are two distinct phases at which a person may need reconditioning and toning up. One embraces hospital treatment, the other the industrial process of putting a man in a job.

In the Ministry of Labour our normal contact with disabled people is neither in hospital nor immediately on discharge; and we find that there are substantial numbers of people among the ordinary clientele of the employment exchanges who, while not needing any obvious medical treatment, do need two things which closely resemble medical rehabilitation. One is a general toning up of the muscles and physique, and the other is a chance to try their capacities out on a range of industrial processes in order to discover what kind of employment is likely to suit them best. It was to give that class of person those two things that we set up our rehabilitation centre at Egham and are now proceeding to set up some twelve or fourteen additional centres, mainly non-residential.

The resemblance between industrial rehabilitation and medical rehabilitation has led to a good deal of confusion both in thinking and in practice. The history of what happened in practice is this: we had no intention of doing anything medical at Egham when we started, but we found that so many of those coming forward to Egham were really in need of medical treatment, such as physiotherapy

for example, that we had to instal considerable facilities of that kind. And that was not because D.R.O.'s were sending forward people whom they should have referred for medical rehabilitation locally.

According to the Ministry of Health, there are 520 general or special hospitals in England and Wales where the establishment of rehabilitation departments might reasonably be expected. In 1943 only 150 of the 520 had rehabilitation departments and, of the 150, 120 had only partial facilities, such as facilities for remedial exercises. In 1946, 333, or 64 per cent. of the 520, had rehabilitation departments, and of these 129 were partial. This means that even if we had wanted to refer people for medical rehabilitation there would in many cases have been nowhere to refer them. Therefore, once more, advances in our field must be accompanied by advances in the medical field, and vice versa.

We might, in practice, look at rehabilitation in three phases, each distinguishable at any rate by virtue of its immediate purpose.

1. The first is what I might call hospital rehabilitation, the purpose of which is to restore a man to full health and vigour. When I was young if one picked up pneumonia, for example, and went into hospital one was kept in bed six or seven weeks ; then one crept around for ten days or a fortnight feeling like nothing on earth, and then was sent home. It is a very great gain that the hospital now has, as one of its objectives, the aim of carrying a man through to the point where he can go back to work, or at any rate is fit enough to face normal life again better, physically and mentally, than under the old regime.

2. Then at the other end is what you do in the more progressive industrial establishments. In some ways this is similar to what the good hospital does but it can be much more specific. It can do much more for the man because in your rehabilitation departments in factories you have a definite production line that you can work to in your treatment, and you have a natural range of jobs to which your rehabilitation can be directly related. In other words you can probably make a man not only fit for work but fit for a particular job.

3. Somewhere between those two comes the third type of rehabilitation that is required by my thesis. It is our special concern in the Ministry of Labour. The man as we pick him up is not in hospital ; he may never have been in hospital ; he is probably not in work and is probably not fit for full-time work. He may be just a problem case. He may have an employment disability rather than a physical disability ; and what that man needs, as far as we can see, is to have his problem assessed, to have the opportunity of adjusting himself to work, and to get some elementary training in the processes of work. That is, as I see it, the place and function of our industrial rehabilitation. It is post-hospital and it is general—as against the specific things you can do, for example at Austin's. In fact I am inclined to think that a great deal of it is training, and I am inclined to think too that when people talk about " training " for the disabled what they really have in mind is not training in the accepted industrial sense of training for a skilled craft but this elementary process that we call industrial rehabilitation.

There is a good deal of nonsense talked about training for industry. For 90 per cent. of jobs in industry a short period of training on the job itself is sufficient. For the remaining 10 per cent. a high degree of skill is needed which is normally acquired only after five years' apprenticeship. But if we are to train people to that degree of skill, we must be sure that they will gain entry to the industry and be accepted by the trade. This means that the numbers we train must be directly related to the numbers who can be so accepted and absorbed into employment on the completion of their training. So it is necessary to be extremely careful of talking in a general vague way of training for the disabled as if it were something that can be " laid on " for all and sundry regardless of what happens at the end of it.

Selective Placement.—The other main function of the Ministry is what I have called selective placing, i.e., the proper selection of jobs for workers and of workers for jobs. We can lay a statutory obligation on employers to employ a percentage of disabled people, but that takes us a very small distance unless everybody concerned (the employer, the works' doctor, the personnel manager, as well as the D.R.O.) is prepared to see that the disabled person is given an opportunity of using his talents to the best advantage.

To give that opportunity requires individual thought. One thing has become perfectly plain : although disabled people may be handicapped along one particular line, the great majority have capabilities that can be fruitfully used, given proper selection of the job for the worker and of the worker for the job. So first of all we want to know about these capabilities. To enable us to give suitable advice about what are the most appropriate jobs in any given case, it is necessary to have proper information about the remaining capacities of the disabled person. That we have tried to get, through the D.P.1 ; and we have now made arrangements to secure through the new Medical Interviewing

Committees that we get not only a written report analysing the functional capacities of the disabled person but also personal and oral advice about what type of work is thought to be most suitable for him.

But a detailed knowledge of the functional capacities is only one half the story; we need to know also the functional requirements of many thousands of particular jobs, and here there is a great gap in current knowledge. Neither the Ministry of Labour nor employers nor anyone else I know has any complete knowledge of what functional capacities are called for by particular jobs, though for certain jobs we have some detailed knowledge, and of others some very general information.

Need for Research

There is urgent need for further research and for much closer investigation into this matter of functional requirements of jobs than any official organization at any rate has so far been able to provide. Through a special working party at the Ministry of Labour, on which Dr. Stewart is the moving spirit, we are beginning to apply ourselves seriously to this. We are engaged at the present stage in trying to discover what has been done hitherto, and then to see if we can find a way forward. But of course it is an immense and highly technical subject. It is largely a matter for background research, and the research to be of value will have to correlate results in many different fields.

Job Analysis.—Job analysis, as it is called, is not merely a matter of job description. What is more, it is not a kind of trade in itself guaranteed to produce summarized data from which individuals can be unerringly allocated within the range of jobs analysed. On the contrary job analysis seems to me of comparatively little practical use unless it is accompanied and directed by many kinds of information that you cannot get from a mere study of the mechanical operations. It is not enough, therefore, to prepare on the one hand a list of disabilities with their different functional assessments, and on the other a list of occupations with their different functional requirements, with a view to matching the two lists up automatically. Number 13 on the one list may not fit number 26 on the other, however much they look on paper as if they ought to fit. For one thing the two analyses would have to cover many scores of disabilities and many hundreds of different occupations; personal factors such as character, age, adaptability, previous experience, and personal interest, will prove to be just as important as the physical disability.

It may indeed well be that the practical value of job analysis is as a guide to training methods rather than as a guide to the solution of the problems of individual allocation to jobs; and for that kind of reason I am inclined to think that much of the work done in America on job analysis is much too facile and much too theoretical to be of practical use for general application. But we are not really entitled to say so unless or until we put the matter to some practical test ourselves. For such a test the Ministry of Labour could supply some part of the raw material, but it would not be competent to undertake the technical research. That would require some body like the Medical Research Council. Consequently, I hope, once we know what we want, to enlist the appropriate expert assistance, and, with the power and resources of a big Government department behind us, to get something really effective done.

DISCUSSION ON MR. TAYLOR'S PAPER

CHAIRMAN: There are two new and important developments that Mr. Taylor has told us about: the development of non-residential rehabilitation workshop centres; and the development of Medical Interviewing Committees on which will be a hospital registrar, an industrial medical officer, and the D.R.O. as secretary, together with outside consultants as required. Is this latter development being done in collaboration with the Ministry of Health?

MR. TAYLOR: Yes. The Ministry of Health is laying this service on for us, and we are guided by them on all matters of this kind—although the responsibility is ours of course for the use we make of their help.

DR. R. WRIGHT (Birmid Industries): Will the personnel on these Medical Interviewing Committees be appointed in a full-time capacity?

CHAIRMAN: Appointments are on a sessional basis, and are not whole-time appointments. The sessional fees have been agreed by the B.M.A. with the Ministry of Health.

DR. HEALEY: Have any general practitioners ever been asked to fill in D.P.1?

MR. TAYLOR: In respect of private patients, no; but as part-time doctors in the insurance medical service, yes.

There are two purposes for which we need medical evidence under the Act. One is when a man who is in employment comes along and says he is disabled and wants to be put on the register. If the disability is obvious, like the loss of a limb, we can register him straight away: if it is not so obvious we ask him to produce some medical evidence, and we give him a form

(D.P.32) to be filled in by his doctor. This merely certifies that he has a disability and indicates its nature. As this man is in work and is merely claiming the right to be registered it is for him to pay the fee. But if the certificate on D.P.32 is still not sufficient for our purpose we refer him to a doctor in the Insurance Medical Service for a report on D.P.1—and we pay for that.

The second purpose is for the unemployed man, where we need a detailed medical report about his disability for selective placing purposes. Here too we use the form D.P.1 through the Insurance Medical Service—and we pay the fee.

When the form was first devised it was hoped that the hospitals, and to some extent the medical profession, would use it quite generally, but for a number of reasons this has not been the case. Only the Ministry of Pensions and Service hospitals, some public hospitals, and a few hospitals with which we have special contacts, have ever used the form D.P.1 to any extent. The Ministry of Pensions' hospitals use it fully. A few general practitioners who are keen on functional analysis have also used it, but it has not been generally accepted by the medical profession.

DR. HEALEY: In our district of Stoke-on-Trent, so far as I know, only the Regional Medical Officers and the part-time Regional Medical Officers of the Ministry of Health have filled in form D.P.1. Can you say whether that filling in has been satisfactory or not?

MR. TAYLOR: Without a doubt, yes. We are perfectly satisfied with the results and we understand that the doctors who use it make no complaint about it.

DR. HEALEY: When you have a part-time Regional Medical Officer doing this work he is sent four or five people in a session of about two hours, and the fee for that is two guineas. But normally, in N.H.I. practice, the medical officer sees nine or ten cases. Why is this?

MR. TAYLOR: The fewer seen the better service, I expect. And the form does require some care and time to complete.

DR. HEALEY: It requires a full examination; then filling in the form is easy.

MR. TAYLOR: I agree. It is the examination that takes the time, not filling in the form. The hospital's difficulty is that, when the hospital takes in a man to operate on his arm, they have the man in for that specific purpose, and keep their record relevant to that purpose, but they do not, for example, test his eyesight. So when we ask for a D.P.1, which asks about this and many other questions, it means that the hospital has to undertake special examinations and write up the case from a different angle. These are real difficulties which I fully appreciate.

DR. HEALEY: In our hospital at Stoke we have nothing called a rehabilitation department, but we have a physiotherapy department, which I think is all you want. Perhaps it is only a matter of terminology.

MR. TAYLOR: Your hospital would come into the group which I described as having partial facilities for rehabilitation.

DR. HEALEY: I read an article in the *British Medical Journal* (1947, **2**, 919) recently by an almoner who criticised your training arrangements. You may get disabled workers trained, but are they going to be accepted by industry? In the case she cited it was finally decided that the man could do nothing but be a shoe repairer, and yet there were several quite hefty delays in the process of getting him a course of training. This man's only chance was to be a shoe repairer.

Arising out of this, what arrangements have you got with the Association of Master Shoe Repairers or the appropriate trades unions that they will accept up to 3 per cent. or in some cases say 10 or 30 per cent., of disabled workers?

MR. TAYLOR: We have agreements with all the trades unions and with employers as to the numbers which the particular craft can absorb. Within the limits of those numbers we can train men for the craft with the assurance that they will be accepted by the trade.

DR. HEALEY: They will not be cold-shouldered?

MR. TAYLOR: No, provided they come within the terms of the agreements. There is a limit to the number of people who can be admitted to any trade. It is perfectly true that training is a remedy for disability, because what better compensation can you give a man for a handicap than to give him a skill; but, against that, you have the practical difficulty that there is no point in training a man unless he will have an opportunity of earning his living in the trade for which you train him. I may say we have trained, since we started under this Act, some 25,000 disabled people, in the real sense of training for skilled crafts. So industry, of one kind or another, has actually taken on 25,000 disabled persons specifically trained by us.

DR. HEALEY: There are no untouchables?

MR. TAYLOR: No; not in the sense of refusal to countenance training.

CHAIRMAN: In the printing trade the minimum time of training, in any section, is apparently some years. I raised this point of taking on disabled men recently with a master printer. He described the difficulty he had with the unions on this matter of dilution with what they call "semi-skilled" dilutees. There was difficulty in getting disabled persons into this trade unless they were fully trained craftsmen.

MR. TAYLOR: There may be difficulty in some union branches. You make an agreement with headquarters and it does not always get down uniformly to every individual branch. But generally speaking the trades unions have been generous to us on admission of the disabled.

DR. HEALEY: The letter that came to the secretary of our hospital about Medical Interviewing Committees did not say anything about any member of the Committee being of "registrar" standard.

MR. TAYLOR: He has to be a person of some professional standing.

DR. W. T. BRUNYATE (Ministry of Health, Birmingham): As I understand the position, we want a man of the highest status who is prepared to give the time and effort wanted in this work. Stoke now has the first of these Committees to be set up in this Region and we have

been lucky to get men of the status of Mr. Zinck and Dr. Healey. We have not, of course, been able to give any ruling on how much time these posts are going to involve, nor do we know how frequently the committees will have to meet. My only doubt is whether Mr. Zinck and Dr. Healey will be able to give us as much time as will be required. I think it possible that they may find it necessary to put in an additional deputy who can spare more time than they are able to. For a start, however, we are fortunate to get these two men, one an honorary assistant surgeon and the other an honorary assistant physician on the staff of the main local hospital. We are hoping to appoint an industrial member to this Committee at an early date and then meetings will be able to begin.

CHAIRMAN : Could you tell us what type of person you hope to appoint as the industrial member.

DR. BRUNYATE : A man who has extensive experience of industrial medicine. The question arises again whether such a person will be able to give the amount of time involved. I have heard the suggestion that these committees may have to sit six sessions a week, and if the chairman has a deputy and the industrial member has a deputy that will mean they will each sit three times a week. Clearly a man who is a full-time industrial medical officer is not going to be able to give that amount of time. So whom shall we be able to find ?

I had one other point. One of the things which Mr. Taylor only touched on is the training of the D.R.O.'s. I fully accept myself what Mr. Taylor said about what is required in a D.R.O. and that their training is a matter for the Ministry of Labour. D.R.O.'s who attend meetings will pick up valuable information about medical terminology which will enable them to appreciate what they get on the form. The proposition has been made that special training courses in hospitals lasting a fortnight or three weeks should be held at which D.R.O.'s should attend full-time with a view to obtaining a smattering of medical knowledge. We have not got any such courses established in this Region ; and I personally doubt whether this kind of training would prove valuable to them in their work. I would very much like to know Mr. Taylor's views on this subject.

MR. TAYLOR : I am not really competent to express a view. There has been discussion on the point by the Medical Committee of the National Advisory Council* and the chairman is a member of that Committee. I should only embark on training of that kind to the extent and in the form recommended by the Medical Committee.

CHAIRMAN : There is a good deal of difference of opinion on the training of D.R.O.'s. Would Mr. Taylor care to elaborate the point ?

MR. TAYLOR : Dr. F. S. Cooksey (Adviser on Physical Medicine to the Ministry of Health) produced at our request for this Medical Committee a programme and curriculum for a three weeks' course. There was a division of opinion among the medical men on the Committee and among the laymen who attend, as to how far you can either usefully or wisely go in trying to transmit a smattering of medical knowledge to the layman. Dr. Cooksey eventually agreed to see if he could produce something simpler ; and there the matter rests at the moment.

CHAIRMAN : The problem of training probably varies in different regions.

DR. W. J. LLOYD (Guest, Keen, and Nettlefolds) : On the question of training D.R.O.'s, there has been correspondence between Dr. Brunyate's department and the University as to the best course to lay down. After consideration we (the University Department of Social Medicine) put up a scheme to the Ministry of Labour that the best thing to do was to put the D.R.O.'s with an industrial medical officer for two or three weeks and let them have discussions about cases. We felt we could do a great deal to help in this way rather than by setting up a course.

A second point I wish to make is that the standard of treatment given in hospitals up and down the country is not as high as it should be. I am convinced that there are disablements which should never arise and one of the chief drives should be to improve standards of treatment, and continuity of treatment right through. A man came to see me yesterday who had been burnt on the legs. After attending a certain hospital and after being skin-grafted he was sent home to live with another old man, having been given penicillin cream to dress his own wounds. The skin graft was broken down and all the money spent has been wasted just because the hospital doctor did not ask the district nurse to call.

Another point on the medical side is that we do want, if we can, to implement this Act better by the education of the medical student in its principles. When he starts clinical work in hospital wards the student is thirsty for the knife—I suppose we all were at that stage—and it is difficult to put over the social side to them. It is important to do this also even to senior members of teaching staffs at hospitals.

MR. TAYLOR : May I say one thing that comes to my mind arising from the early part of Dr. Lloyd's contribution. There are of course two types of training. We run training courses, within our own Department, for all the jobs done in the Ministry of Labour ; that is, we run our own courses of lectures. That is ordinary departmental in-training. The course that we are talking about, however, is a higher type of thing altogether laid on from outside the Department. If this outside training is not feasible it does occur to me that those of you, particularly from the University, if you are willing to help, could do so if there is the kind of information that you can get across to the layman in an hour's lecture or a morning session at one of our in-training courses.

DR. LLOYD : This is really the same type of training as Dr. Cooksey suggested. It is so difficult to switch from one place to another and get coaching that the only thing is to get the D.R.O. to live with the industrial medical officer and at the end of a week discuss all the points and talk about the cases as they come along rather than by a lecture. I believe that in a large industrial establishment there is an abundance of clinical material. I do not think that a lecture set-up will produce very much at all.

MR. TAYLOR : We are faced with the problem of some method of getting our D.R.O.'s to understand your language and thought. And you see how the idea grows. Somebody or other advises us that the courses of in-training for D.R.O.'s do not give them any knowledge

* This committee consists of Sir Reginald Watson-Jones (Chairman), Professor T. Ferguson, Professor R. E. Lane, Dr. Maxwell Jones, and Dr. Donald Stewart.

about medicine, so what we ought to do is to give them three-week courses on medical matters. At Glasgow, Manchester, and London we tried that and there was division of opinion about it. We thought it was pretty good but the doctors did not. So then we said, let's try a more elementary kind of thing. But somebody says a little knowledge is worse than useless. So we still want the knowledge but we have not been able to find an acceptable way of getting it. There may in fact be no safe way of giving a layman just the right amount of medical knowledge.

DR. WRIGHT: It would be a good thing for industrial medical officers to invite D.R.O.'s to come and see them at their factories.

MR. TAYLOR: That would be excellent, especially in factories with rehabilitation departments.

CHAIRMAN: I think both Dr. Wright and Dr. Lloyd would agree that if the D.R.O.'s were to go to industrial medical officers it should be to those in firms with a positive and definite rehabilitation and resettlement policy.

MR. TAYLOR: I referred to rehabilitation departments because we are anxious to develop our own rehabilitation facilities. I should like to say that we are trying at the moment to lay on a non-residential industrial rehabilitation centre at Holyhead Road in Birmingham. The chairman has a close interest in this venture; would he care to say something about it?

CHAIRMAN: This new centre is evidently not to be confined to any one type of disability; and that difficult group of unemployables, creating a fascinating problem in resettlement, is to be catered for if at all possible. Final details are not yet available, but the factory, at Holyhead Road, from the point of view of factory premises, is first-class. It is now important that the Ministry of Labour should find the right manager and the right medical officer. Only thus can success be assured. Other officials suggested at the centre are a vocational guidance officer, a social welfare officer, a physical training instructor, and several occupational supervisors.

Places will be reserved for some 120 individuals, men and women. They will be recruited through hospitals, general practitioners, industrial medical officers, and Employment Exchanges. Arrangements have been made for physical toning-up, for example a gymnasium has been provided. In my view, however, the main way by which men can be reclaimed for industry is through work processes, if possible productive work. Men and women will be paid financial allowances on a fixed basis, probably that in force in Government Training Centres.* Hot mid-day meals would be provided five days a week, at a cost of 5*s*. per week.

It is essential that the medical profession in Birmingham should become well-informed on this new centre so that they can decide on the desirability, or otherwise, of referring patients to it. The Ministry of Labour appreciate this point and have agreed to prepare relevant literature for circulation to hospitals and doctors. It is possible that these new centres may become important training centres for D.R.O.'s and offer facilities for research.

DR. J. SQUIRE (Medical Research Council): I would like to underline Dr. Lloyd's point that hospital standards of treatment and rehabilitation are generally low. The other day I saw a man, employed in a saw mill, who had lost several fingers of his right hand. All the hospital had done was to let the hand heal; but surely plastic surgery would have been useful? I would like to feel that we recognize the fact that this man could still have had a lot done for him. Where an adequate rehabilitation department exists in a hospital it should be concerned with the job to which a man should return, and the maximum functional ability that can be obtained. A man with a broken leg who could do his job with a stiff leg might go back soon to work; but if there was a chance of giving him a mobile leg then he should be kept under treatment long enough irrespective of his work.

Mr. Taylor has said that 90 per cent. of jobs in industry do not require any training. I would like to qualify that by claiming that the standard of training on the job is at present very, very low, and that lack of training is responsible for much medical disability in the early months of employment. For example, many patients do not even know how to wash their hands, and after a time may get dermatitis out of ignorance. Perhaps the same problem arises when you take men out of rural jobs to city jobs or vice versa; training in how to look after themselves should be part of the training.

MR. TAYLOR: That kind of education would be part of our industrial rehabilitation schemes. On your first point, you are of course asking rather a lot of a layman to know whether a man can be medically made more of. I wonder how far a layman, taking over a disabled case from a medical authority, can do anything except assume that the medical authority has done its job?

DR. SQUIRE: Perhaps your new centres will be big enough to employ a medical officer, just as the industrial centres do, to watch over progress.

CHAIRMAN: It is proposed that each will have a part-time medical officer.

PROFESSOR T. MCKEOWN (Birmingham University): It is obvious that this problem of resettlement is very complex. Mr. Taylor touched on the question of analysis of the job and the need to know very much more about jobs. It seems to me that, where lay people are dealing with medical matters, there is always a danger of being too respectful of medical opinion. How far is the Ministry of Labour likely to interest itself also in the question of the medical side?

MR. TAYLOR: The answer lies in what I said to you about having to correlate results in a variety of fields. What we are proposing to do at the moment is to determine, as far as we can, the different kinds of research that we think are needed. Some of the factors lie in our field, others in the medical field, and some in the sociological field, but we hope eventually to persuade some really competent body like the Medical Research Council to undertake research into the whole of the factors. In other words the Ministry of Labour would not attempt to start research of this comprehensive character on its own.

* Scale of weekly allowances (for persons over 20 years of age) paid at Government Training Centres.

	Men	*Women*
1. Persons without dependants	70*s*.	57*s*.
2. Persons with one or more dependants, children under 16, but no adult dependants	75*s*.	62*s*.
3. Persons with one adult dependant	80*s*.	67*s*.
4. Persons with one adult dependant and one or more dependant children	85*s*.	72*s*.

N.B.—These allowances are in no sense wages, and are not subject to deduction of income tax or National Insurance contributions.

PROFESSOR MCKEOWN : On this difficult question of the D.R.O. and his training I think anyone will agree that, faced with the practical problem of starting a new service, one has to do the best one can. Does Mr. Taylor think in the long view that the lay officer with only the knowledge or training he can get at the Ministry of Labour is likely to meet what are clearly very complex needs? You want to arrange something directed to purely practical needs. Universities have very fixed ideas of training in social science, medicine, etc., and do not respond always to needs in industry. But we now have a situation in which there is a need for a very important type of training. How far we carry the training depends upon the ultimate objective of the Ministry of Labour. The two-week training is very difficult; you cannot get anything useful in that time. But what kind of service are you aiming at? Is the present D.R.O. set-up the final pattern for industrial resettlement?

MR. TAYLOR : The answer is that there is nothing final about the present arrangements. We started, as you know, during the war at a time when manpower was at its lowest. We had parted, for example, with some 1,800 young men from the Employment Exchange service alone to the Forces. So, being faced with this new service, what did we do? We had a fair number of ex-servicemen from the 1914–18 war who would, at any rate, know what it was like to be disabled; and so we put that kind of person from our staff on to this work, but that did not mean they had any great knowledge. It was a stop-gap arrangement but sensible enough of its kind.

We have in the last two years taken into our service in the Ministry of Labour, through the Civil Service examination system, close on 4,000 young men of examination standard between the ages of 21 and 30, and I am told they are very good. We have still a further 2,000 to take in in the next eighteen months or so. So it can be seen that we are adding 6,000 men of good fresh blood to the Exchange Service. They will not all come on to the D.R.O. work at once of course, but you will agree that the situation promises well for the future.

But even with good young men we have still to solve the problem of how far the layman will ever be competent to perceive the full significance of medical considerations. And I just do not know the answer to that except that we are hoping to get some kind of help from the field of education, including the universities. We recently asked Mrs. Williams, Secretary of the Social Science Studies Board of London University, to do a special survey for us of how far specialized knowledge is relevant to our work and available. She has already produced a valuable report which we are in process of studying with her. I think that some fruitful ideas will come out of that, and we shall probably be approaching universities as to what there is in their teaching which is relevant to our work, and which can be transmitted to our staff by courses of training or further education.

PROFESSOR MCKEOWN : Can Mr. Taylor tell us if the Ministry have had any chance of assessing the results of the Act, such as a follow-up of cases from hospital sources, how long they remain in work, and how satisfactorily they are placed in work?

MR. TAYLOR : I do not think that we have anything you would call follow-up in the academic sense. What we do is to follow up in the popular sense at stated intervals any cases that are not in touch with us. But of course that is not much use for research purposes or tabulated results. It is merely a practical method of checking whether the person is satisfactorily settled, and whether he needs any further help from us or not. We do, however, follow up especially those who have been through Egham.

MR. HALSTEAD (Psychiatric social worker, present as a guest) : The form D.P.1 does not seem to be well enough developed for psychiatric cases although at hospital we fill it up if asked. I thought that the Disabled Persons Register was going to be swollen to enormous proportions, but, as a member of a District Advisory Committee, I have been instrumental from time to time in turning down applicants who were in no sense psychiatric casualties.

I know a case of a man aged 25 just out of the army, who is too old for an apprenticeship. The trades unions will not accept him. Could Mr. Taylor comment on this?

MR. TAYLOR : If he is now 25 he should have started his apprenticeship before he went to the war. This type of case is frequently met with. A person goes to the war aged 18 and comes back 25, and then at that stage says, "If I had my time over again I would have been an engineer." But of course he should have thought of that at 16 when he was the right age.

CHAIRMAN : I believe that Mr. Halstead has drawn up a scheme on the supervision and resettlement of epileptics.

MR. TAYLOR : Have you seen the "epileptic" leaflet we have issued? We got Dr. Tyler Fox to describe the factors to be taken into consideration in employing epileptic sufferers; it is a leaflet we give to employers.

MR. HALSTEAD : We are collecting names and case-records of epileptics in Birmingham, and so far have upwards of 100, that is about a fifth of the population of epileptics in Birmingham. It is astonishing the number of jobs they are doing. We are ranging cases according to their disablement, and are wondering if the Ministry of Labour have any training they could have.

MR. TAYLOR : I would not like to express an opinion off-hand, but I would like to have that report. I may also mention that the Disabled Persons Employment Corporation are employing some epileptics at one of their Remploy factories. It is a small experiment and undoubtedly one of the things found is that the epileptic improves under work.

MR. H. S. GOSNEY (Midlands Regional Controller, Ministry of Labour) : I might usefully say a word on the question of D.R.O.'s, as the person responsible in this Region for their work. I take the view, having regard to the circumstances under which we started the scheme, that the D.R.O.'s are putting up a good show, but I should be the last to claim that we are satisfied with ourselves. The D.R.O.'s are doing a lot of good work in their own field and getting quite good marks from industry. But it is not the job of a D.R.O. to attempt to evaluate medical considerations or to pretend to be more than a specialized placing expert. It is not always realized that the industrial world has its own complexities and its own limiting factors. On the

question of follow-up, I suggest one has to be a little careful; for not everybody likes to be followed up. What is more, personal inquiries tend to be unsettling. There is a lot of restlessness about, and it will often happen that a person who is doing quite well in some job will give you fourteen reasons why he should leave it if you once unsettle him. We all tend to think there must be better jobs than the one we've got.

DR. A. A. WHITE (Austin Motor Company): There is a point in connexion with the training of D.R.O.'s which is of interest. These young people that you are bringing in, age 21 to 26, apparently members of the Civil Service, where are they going to get the industrial knowledge which you said was so important?

MR. TAYLOR: I said they would not necessarily be coming on to that particular type of work for some time. They will pick it up in the same way as Mr. Gosney and the others have done, by daily contact with industry.

DR. WHITE: What chance are they having to do this?

MR. GOSNEY: We have a highly-developed training course for new entrants. They are taught the structure of industry and the meaning of occupational terms, and it is part of their training to visit factories. We have study-groups which take up industrial organization, industrial job analysis, and so on; these give the new entrant a good idea of local industry. The field is gradually widened from these beginnings.

MR. TAYLOR: The trouble is, of course, that one cannot get people into the Ministry who have served an apprenticeship in industry. But the Civil Service method of recruitment does by a mixture of examination and selection provide in normal times a good type of entrant who can be trained up to any pattern you want.

CHAIRMAN: Before closing there is one point I would like to mention. This meeting was called primarily to discuss methods whereby Ministry of Labour officials in this area could make closer and more effective contact with the medical profession. I think contacts have been initiated in a small way, by this meeting. But further liaison may be necessary and the Group Secretary, Dr. J. G. Billington, will, I know, be only too happy to make any further contacts or arrangements that the Ministry wish.

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POISONING BY METHYL MERCURY COMPOUNDS

BY

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In 1940 Hunter and others, reporting on cases of poisoning by methyl mercury compounds, showed that those working with certain organic mercury derivatives are exposed to great danger. In 1945 Herner collated the cases of poisoning by alkyl mercury compounds recorded in the literature. The seven cases hitherto published show a characteristic clinical picture beginning with a sensation of numbness in the tongue and weakness of the hands and feet. Motor inco-ordination followed, and the faculty of walking and the power of speech rapidly deteriorated. Defective vision and hearing occurred in several cases, and there was often mental torpidity, which led in some cases to complete dementia.

During the war of 1939–45, when Sweden was virtually cut off from the rest of the world, the manufacture of methyl mercury compounds for use in seed-dressing and wood-preserving was taken up. In consequence of this certain hygiénic problems arose as well as a number of typical cases of poisoning, two of which ended fatally. A report on these experiences seems justified. First the condition of the premises will be described at the time when the accidents took place, after which a series of cases will be presented. Finally the preventive measures adopted will be discussed.

The Process

The fungicide of choice is methyl mercury hydroxide. Briefly it is produced by shaking together in ultra-violet light methyl iodide and metallic mercury, to form methyl mercury iodide. During this process the methyl iodide and the mercury are kept in glass bottles, which are opened twice every day in order to release the excess in pressure. After these have been shaken for ten or twelve days the excess of methyl iodide is evaporated off in closed vessels at from 60 to 70° C., and the remainder of the metallic mercury is removed. The methyl mercury iodide forms a compact mass, which must be bored away before it can be emptied out of the bottles. The methyl mercury iodide is then purified by extraction with acetone in a closed system. The purified iodide is mixed with silver oxide, when the final product, methyl mercury is formed. All the above processes are carried out in a fume chamber. When opening the bottles, and on all other occasions on which methyl mercury iodide or hydroxide came into contact with air, the staff worked in masks, coats, and rubber gloves. The product has been used for seed-dressing and wood preserving in a solution of 7 per cent. or 0·25 per cent. The mixing of these final products took place in well-ventilated premises, and on these occasions too, the staff wore masks and protective clothing.

Seed-dressing was carried out in an automatically rotating drum at the place where the cases of poisoning occurred. The machine was filled and cleaned without any particular precautionary measures being taken. The seed was thrown out from the machine through a pipe on to a lower floor, where from four to six men were busy packing the seed, after which it was stored in the same room.

Wood-preserving took place at the saw-mill, by spraying a 0·25 per cent. solution of methyl mercury hydroxide on the wood. When that portion of the liquid which was not absorbed by the wood was again collected, it was strained through cloth and used again. The wood-preserving fluid was prepared in open vessels in badly ventilated premises.

Case Reports

Case 1 occurred in a factory for making methyl mercury hydroxide, Cases 2 to 4 in a seed-dressing firm, and Case 5 in a saw-mill.

Case 1.—A man of 32 had been working for three-and-a-half years in the factory where methyl mercury was manufactured. He was specially occupied with the extraction of methyl mercury iodide and also with releasing the excess pressure in the bottles in which the methyl mercury iodide had formed. He was extremely careful in his work and observed all the protective precautions in detail. At the beginning of April, 1944, he began to complain of giddiness, his fingers felt "funny," and the tips became numb. In the middle of

May he began to speak indistinctly and complained of numbness in the tongue. He began to walk unsteadily and found it difficult to keep his balance. Towards the end of May, owing to his trembling hands, he could not even drink a cup of coffee without help. He became irritable, and lost much weight though there were no intestinal symptoms. He was at first regarded as being hysterical. He was admitted to hospital on June 1, 1944, after which his condition deteriorated rapidly, and by the end of the month he could not stand upright. The ataxia increased. He felt a numbness in the hands, the tongue, and round the mouth, though it was not possible definitely to prove any defect in sensibility. His hearing became worse, and his speech was barely understandable. He could scarcely write at all. His face took on an almost euphoric expression. From the beginning of July his condition improved, the ataxia decreased, and the hearing improved. By October, 1944, he was able to feed himself. In January, 1948, he was still suffering from ataxia and could not eat properly. He had not recovered mentally. (For more details see Herner, 1945.)

TABLE

MERCURY CONTENT (μg/G) OF ORGANS TAKEN FROM FATAL CASES OF METHYL MERCURY POISONING

	Case 2	Case 5
Different regions of brain ..	4·5–5·1	4·0–9·7
Spinal cord		3·8
Pituitary gland	25–35	<5·7
Liver	19·6	14·1
Lung	3·9	2·1
Spleen		4·5
Kidney	30·4	3·0
Intestine	1·3	2·3

Case 2.—A man of 23, from Aug. 16 to Sept. 16, 1944, had been occupied in the packing of a seed-dressing containing methyl mercury. He was taken ill about a month after the work was completed and felt a numbness and a stinging sensation in the hands. Towards the end of October in the same year it was difficult for him to keep his balance and to walk, and he noticed that he could not hold a filled glass steadily. He began to speak indistinctly. On many occasions he suffered from diplopia. According to his family his temper had deteriorated before he was admitted to hospital on Oct. 31, 1944. He was then found to have an unsteady walk, and he moved clumsily and insecurely. From Nov. 4 onwards the patient gradually got worse, throwing himself about uneasily in bed and holding his arms and legs in strangely stereotyped positions. On Nov. 8 there was extreme motor unrest which increased, and he died the following day. At first the patient was thought to have encephalitis. Analysis of some of the organs showed high figures for mercury (see Table).

Case 3.—A man of 22 had the same work as Case 2. On about Nov. 4, 1944, he began to feel a tingling sensation in his hands, feet, and round his mouth, and this continued for about a couple of weeks. There were no other symptoms.

Case 4.—A man of 18 had the same work as Cases 2 and 3. On Nov. 5, 1944, the patient noticed a tingling sensation and a numbness in the fingers, which improved quickly at first, but he still felt it to a certain extent on Dec. 5, 1944. There were no other symptoms.

Case 5.—A man of 57, for five years had on repeated occasions impregnated wood with a methyl mercury preparation. He was taken ill in the middle of December, 1944, with a numbness in the hands and forearms, digital inco-ordination, dizziness, and unsteady walk. He found it difficult to hold his coffee cup steadily, and on one occasion he fell off his bicycle for no apparent reason. The symptoms gradually increased and the patient was admitted to hospital on Dec. 16, 1944.

It was soon impossible to understand what he said. He developed concentric scotomata of the fields of vision and later became completely blind. Towards the end of the month he got more or less uneasy, alternating with periods of deep apathy. He had to be fed through a tube, but he could swallow water. He died on Jan. 2 after a terminal rise of temperature. Before the similarity of Cases 1 to 4 had been fully realized, the condition was interpreted as one of cerebral tumour and the patient was transferred to the neurosurgical department. Analysis of the organs showed high figures for mercury (see Table).

The symptoms here referred to show a striking resemblance to those of cases of poisoning by alkyl mercury compounds previously described. Thanks to these, and especially through the investigations made in two of the cases of the concentration of mercury found in various organs, it has been possible definitely to establish the ætiology.

Preventive Measures

Because of the occurrence of these cases and others, the protective measures at the places of work were improved in many respects.

At places where seed-dressing was being carried out, steps were taken as far as possible to prevent the workmen from inhaling dust and vapours, and to prevent the chemical compounds from coming into contact with the skin. On our advice these steps have been enforced by the state authorities responsible for laws and regulations concerning the safety of the workers. Thus, the seed-dressing plant must be built in particularly well-ventilated rooms, with special suction arrangements to prevent the dissemination of dust and vapours about the premises when the machines are being filled with products containing mercury. The spread of dust must be carefully avoided, and it is advisable to pour in liquids through tubes. When apparatus is cleaned, respirators must be used and both gloves and aprons must be worn to prevent absorption.

Places where the seed is packed must likewise be specially enclosed and well ventilated.

Steps must also be taken to afford workmen employed on mercury impregnation every possibility of satisfactory personal hygiene. A sufficient number of lavatories must always be available. Special clothes and foot-gear must also be worn during work. Meals must not be served at the place where work is being carried on, and when meals are taken clothes must be changed and careful attention paid to personal hygiene. Corresponding arrangements must also be made at places where methyl mercury is used for preserving wood.

Taking into consideration the high degree of toxicity of these compounds, these technical protective measures are not sufficient. It is important to remember that the smallest changes in the arrangements of the plant or in the order of the work may involve risk. It is certainly necessary to analyse the mercury concentration in the air repeatedly and to have the staff regularly examined by a physician.

No conclusion has been arrived at as to what is the upper limit of safe exposure to these mercury compounds in the air. Considering the extremely high toxic effect of metallic mercury, and bearing in mind that some authors give 0·06 to 0·20 mg. per cubic metre as an allowable concentration, a percentage higher than 0·01 mg. per cubic metre of methyl mercury compounds should not be allowed.

In order to test the effectivity of the protective steps taken at the factory for the manufacture of methyl mercury compounds a regular medical control of the staff is carried out. This consists of a monthly physical and neurological examination in which careful enquiry is made of early symptoms. Such symptoms scarcely differ from those generally found in neurasthenics when they think that they have been exposed to toxic risks. It has therefore proved extremely difficult in the case of sensitive persons to distinguish between true mercury effects and neurological symptoms having quite a different origin. In order to overcome these difficulties attempts have been made to prevent persons inclined to neurasthenia from carrying out dangerous work. Consequently, before taking up duties in the factory everyone must undergo a thorough medical examination, after which only absolutely healthy persons without any predisposition to neurasthenia are allowed to work on the premises where mercury compounds are handled. By estimating the mercury content of the blood and urine, it has been possible to check the position to a certain degree. In a considerable number of cases the urine rates have been between 30 and 60 μg mercury/litre urine without the person in question showing the least sign of being affected. On the other hand, there have been some cases with unmistakable but slight signs of mercury effect with a percentage of 50 to 100 μg mercury/litre urine.

From these investigations the conclusion has been drawn that a person should not be allowed to undertake work with methyl mercury compounds which produces a mercury excretion in the urine exceeding 10 to 15 μg litre. Fortunately it has been found possible to attain this.

Summary

A description is given of five cases of methyl mercury poisoning observed at a factory for the manufacture of such compounds, in a seed-dressing plant and at a saw-mill. The cases show a striking resemblance to seven others previously described in the literature. An account is given of the steps, both technical and medical, that have been taken to protect the staff from the risks of poisoning. Particular attention must be paid to repeated environmental and medical examinations, including both blood and urine tests for mercury frequently repeated during the period of exposure.

I wish to express my gratitude to R. Vesterberg for his kind help with the analyses.

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PNEUMOCONIOSIS OF COAL-MINERS

A STUDY OF THE DISEASE AFTER EXPOSURE TO DUST HAS CEASED

BY

ALICE STEWART

WITH THE ASSISTANCE OF

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Introduction

Throughout the nineteenth century the coal-mining industry of Great Britain steadily expanded and the number of workers increased over twenty-fold. By 1831 it was recognized that colliers were liable to develop "miner's asthma" (Thackrah), and in 1857 Cox referred to this disease as "the scourge of the mines." Working conditions at this time were notoriously bad, but in 1842 the first Mines Act was passed, and eight years later a Mines Inspectorate was established. Thereafter ventilation steadily improved, and by the end of the century it was confidently stated that coal-mining was no longer an unhealthy occupation (Arlidge, 1892). Lung diseases such as bronchitis and emphysema were still prevalent among older miners; but, as colliers appeared to be relatively immune to tuberculosis, it was assumed that inhalation of coal dust did not produce silicosis (Oliver, 1902; Collis, 1915; Haldane, 1931).

Thus, when legislation was introduced to enable workmen to obtain compensation for silicosis (Workmen's Compensation Act, 1925), coal-mining was not scheduled as a dangerous occupation, and it was not until 1931 that workers at the coal face were allowed to apply to the Silicosis Medical Board (Various Industries (Silicosis) Scheme, 1931). Since then the numbers of colliers certified by the Medical Board have rapidly increased, and "coal-miners pneumoconiosis" is now recognized as the commonest variant of silicosis in this country.

The tardy recognition of this disease has a threefold explanation. In the first place the true nature of the so-called bronchitis and emphysema was not realized until radiological examination came into general use. Secondly, since coal-miners with dust disease were not particularly prone to develop clinically recognizable tuberculosis, the relationship between "miner's asthma" and silicosis was not appreciated. Finally it was not until the 1880's that there was any large scale development of "hard coal" mining, and it is chiefly in these mines that pneumoconiosis occurs.

In this country anthracite and steam coal (both types of hard coal) are mined in South Wales; and here, according to the only available statistics, the risk of contracting pneumoconiosis is nearly forty times as great as in the bituminous mines of England and Scotland (Table 1). Similar differences have been observed in other parts of the world, and, although the explanation is obscure it is now generally believed that there is a close relationship between incidence of pneumoconiosis and rank of coal, as measured by the non-volatile content of the mineral (Sayers, 1938; Flinn and others, 1941; Moshkovsky, 1941; Hart and Aslett, 1942).

During recent years there have been several changes in legislation relating to industrial lung diseases, which have affected both the numbers entitled to claim compensation and the legal definition of dust disease*. The result of these has been a remarkable increase in the number of coal-miners applying to, and certified by, the Silicosis Medical Board. Undoubtedly this is largely due to increased awareness of the dust hazard, but it is possible that there has also been some deterioration in underground working conditions since the introduction of mechanized mining (Fletcher, 1948.)

Before 1943 the disease contracted by workers in coal-mines was officially known as silicosis, but when

* From 1929 to 1931 miners employed on "special processes concerned with the mining of certain types of silica rock" were entitled to claim compensation for silicosis. In 1931 the Workmen's Compensation Act was amended so that some other underground occupations were scheduled under the Silicosis Schemes, and in 1934 all underground workers were included (Various Industries (Silicosis) Scheme). In 1943 the Act was completely revised, and the Coal-mining Industry (Pneumoconiosis) Compensation Scheme was introduced. Since then surface workers handling coal and coal trimmers have become eligible for compensation.

the Workmen's Compensation Act was revised the legal definition of dust disease was altered and the term "pneumoconiosis of coal-miners" was substituted for silicosis. Under the old ruling three stages of the disease, defined in accordance with the scheme drafted by the International Conference on Silicosis (International Labour Office, 1930) were recognized. After July, 1943, men with a slightly earlier stage of the disease—corresponding to reticulation as defined by Hart and Aslett—became eligible for compensation*.

While it is customary for examining panels of the Silicosis Medical Board to record the stage of the disease as revealed by radiological findings, this is not compulsory. In every case, however, the degree of pulmonary disability is stated, for on this depends the amount of compensation payable by the employer. In practice there is a close relationship between disability award and radiological findings; men with "partial disability" being found in the reticulation and first-stage silicosis categories, and men with "total disability" in the second- and third-stage silicosis categories.

Since no provision has been made for periodic examination of workers in the coal-mining industry, the only official statistics relating to incidence of pneumoconiosis are those compiled by the Silicosis Medical Board, which has, since 1931, handled all applications for compensation from workmen employed in occupations recognized by the Workmen's Compensation Act (Silicosis and Asbestosis Medical Arrangements Scheme, 1931). The Board usually bases its decisions on a single clinical and radiological examination and, if a man is found to be "suffering from the disease to such an extent as to make it dangerous for him to continue in the process," it has the power to suspend him from work. In practice no coal-miner who is certified as suffering from silicosis or pneumoconiosis is allowed to work underground, and once he has left the industry he is unlikely to be examined again. However, if a relative claims further compensation on death, the Board is informed and an autopsy is made.

The Present Investigation

In 1945, when the present investigation was planned, the Silicosis Medical Board was suspending men from the South Wales coalfield at the rate of over one hundred a week. More than 10,000 cases of pneumoconiosis had been reported, and the country was faced with the problem of providing alternative work for these disabled men. The Government were anxious to implement a rehabilitation scheme (Ministry of Fuel and Power, 1944), but were hampered by not knowing what type of work was most suitable, or whether men with pneumoconiosis suffered from a latent form of tuberculosis which might endanger other workers. Although several writers had described the disease as it occurs in South Wales (Cummins and Sladden, 1930; Welsh National Memorial Association, 1931; Williams, 1933; Harper, 1934; Amor and Evans, 1934; Sen, 1937; Gough, 1940; Hart and Aslett, 1942; Belt and Ferris, 1942; etc.) only one small follow-up study had been reported (Aslett and others, 1943), and it was not known whether the disease continued to progress after exposure to dust had ceased.

It was decided, therefore, to design a socio-medical survey which—in addition to revealing the overall mortality in the certified population, the incidence of open tuberculosis, and any clinical or radiological changes that might have occurred after leaving the mines—would also show what proportion of men in early and late stages of the disease were able to do full-time work, and whether there were any indications that the disease had been affected by subsequent occupations. The survey was begun in November, 1945, and was completed in December, 1946, and only men certified by the Silicosis Medical Board between 1931 and 1944 were included. None of these men had worked underground or handled coal on the surface after being examined, so that it could be safely assumed that there had been no exposure to dust between the two examinations.

The incidence of the disease in different pits in South Wales had been computed by the Ministry of Fuel and Power, and copies of the certificates issued by the Silicosis Medical Board on behalf of men employed in every mine were available from that department. Since miners necessarily live within travelling distance of the pit where they work, these records provided a convenient starting point for the present investigation; and, before a preliminary survey was instituted to discover the present whereabouts of the certified men, a series of "Mines Lists" was obtained from the Ministry. On these were recorded the names of the men from each pit, together with the address, age, date of certification, and disability award. By consulting the records kept by the Cardiff and Swansea panels of the Silicosis Medical Board it was possible in most cases to add the *x*-ray category, and the date and

* *Reticulation* is defined by Hart and Aslett as "a fine network shadow, sometimes sharp and lacelike in appearance but more often blurred, which occupies from half of one lung field to the whole of both fields, and is as marked at the periphery as at the hila."

The radiological counterpart of *first-stage silicosis* is "appearances not less than the presence of nodular shadows together with an increase of hilar shadows, linear shadows, and pulmonary reticulation." Three sub-groups are recognized: (*a*) nodules present but localized; (*b*) nodules more numerous; (*c*) nodules generally distributed throughout the films but still discrete.

Second-stage silicosis is described as "nodulation with larger areas of coalescence"; and *third-stage silicosis* as "massive consolidation."

TABLE I

COAL-MINERS CERTIFIED (DURING LIFE) BY THE SILICOSIS MEDICAL BOARD: SOUTH WALES AND OTHER REGIONS, 1931–1945

Period	South Wales		England and Scotland
	Total	Included in Survey	Total
1931–2	143	100	16
1933–4	364	254	38
1935–6	477	324	66
1937–8	632	391	72
1939–40	823	580	83
1941–2	1,218	695	94
1943–4	2,699	1,431	612
1945	4,180	—	574
Total..	10,536	3,775	1,555
"Incidence" of pneumoconiosis *		8·6%	0·3%

* Men certified 1931-1945 expressed as a percentage of the underground working population in 1931.

cause of death in the fatal cases. In addition, all the original films were available for inspection.

By the end of 1944 over 6,000 miners employed in South Wales had been certified by the Silicosis Medical Board, and between seven and eight hundred deaths had been recorded. These men came from pits in all parts of the coalfield, but the number of cases varied from none to over three hundred in different pits. The "high incidence" pits were mainly in the western part of the coalfield where anthracite is mined, but some steam coal pits in the central part of the coalfield had been responsible for more than a hundred certifications.

In view of geographical difficulties, and the elaborate transport arrangements required to bring patients to Cardiff to be examined, random sampling was not attempted. Instead two regions, one in the anthracite area and one in the steam coal area, were defined, and a preliminary survey was made to discover the whereabouts of certified men from the pits situated in these regions.

Colliery officials had records of men who had remained in receipt of weekly compensation, but a large number had settled their claims and were no longer on the colliery books. Fortunately the majority had remained in touch with the Miners' Federation, so that no great difficulty was experienced in tracing men who had changed their address since certification. Surprisingly few had left the district, and during the survey 3,435 of the 3,775 men from the two regions were traced.

In view of misunderstandings which may arise when men in receipt of compensation are asked to undergo examination, meetings were arranged in order to explain the disinterested object of the enquiry. These were remarkably well attended, and the opportunity was taken to circulate a brief questionnaire relating to employment since leaving the mine. The men showed themselves keen to co-operate and this questionnaire was later circulated to all the men who were traced. In this way answers were obtained from most of the survivors, which were found to be substantially correct when checked by cross-questioning men who afterwards received a medical examination. In addition a large number of deaths which had never been reported to the Silicosis Medical Board was discovered, and in most cases the date and cause of death ascertained.

Statistical Analysis of Findings.—In the following account no attempt has been made to distinguish between men from the anthracite and steam coal pits unless the findings revealed a statistically

TABLE 2

1946 SURVEY: RESULTS OF PRELIMINARY INVESTIGATION*

	Date of certification		Results of Survey: Untraced %	Surviving %	Dead %	Total %	Total No.
Early Disease Group	1931–6		9	49	42	100	215
	1937–42		7	74	19	100	692
	1943–4		10	89	1	100	1,003
	Total	%	9	80	11	100	
		No.	169	1,533	208		1,910
	Mean age at certification in years		46·4	45·9	51·8	46·3	
Advanced Disease Group	1931–6		13	16	71	100	463
	1937–42		7	53	40	100	974
	1943–4		9	79	12	100	428
	Total	%	9	50	41	100	
		No.	171	926	768		1,865
	Mean age at certification in years		49·5	49·1	51·0	49·9	

* The data cover the certified men from the anthracite and steam coal regions included in the preliminary survey. The early disease group consists of the men certified as having reticulation or first-stage silicosis, and the advanced disease group those certified as having second- or third-stage silicosis.

significant* difference between the cases from the two regions. Since, however, the investigation revealed a considerable difference between men with early and advanced *x*-ray changes, both in mortality rates and clinical findings, the cases have been divided into two main disease groups. *The "early" disease group includes all men certified as having reticulation or first-stage silicosis*, and the "*advanced*" *disease group all those in the second- and third-stage silicosis categories*. In the few cases (less than 10 per cent. of the total) where the *x*-ray findings were not recorded by the Silicosis Medical Board, the disability award was used to decide the disease group, "partially disabled" men being included in the first group, and "totally disabled" men in the second.

Early Disease Group (1,533 survivors, 208 deaths, 169 untraced).—The early disease group included just over half the total number of men, the majority of whom had been certified for less than four years and only 10 per cent. for more than ten. Over three quarters of the men were between 30 and 60 years of age when certified, and the average age of the group at certification was 46·6 years. Overall mortality among those who were traced was 12 per cent., but there was a close relation between the proportion surviving and the interval since certification, so that although nearly half the men certified before 1937 were dead, nearly all those certified after 1942 were still alive. The death rate was higher among older men, and there was a difference of nearly six years between the average age of survivors and of men who died (Table 2).

Advanced Disease Group (926 survivors, 768 deaths, 171 untraced).—The advanced disease group originally included nearly as many men as the early group, but by the time of the follow-up there were far fewer survivors. This was due partly to the fact that the former contained the bulk of the long-standing cases, and the latter most of the men certified since 1942. But the contrast was due mainly to a real difference between the mortality rates. For instance, 12 per cent. of men with advanced disease who had been certified since 1942 were known to be dead, compared with only 1 per cent. in the early group.

Men with advanced disease tended to be slightly older than those with early disease, and the average age at certification was 49·9 years. There was, however, a difference of only two years in the mean ages of survivors and those who died.

Answers to Employment Questionnaire.—A more detailed analysis of the answers to the employment questionnaire will appear in a separate report. Here it need only be said that certain differences were found between men who lived in the western part of the coal-field, which is a rural area, and those who lived in the more densely populated region in the centre. For instance, there was a higher rate of unemployment among anthracite miners, and those who did find work were often employed out of doors, whereas many steam coal miners worked in factories. More men from the anthracite mines had remained in receipt of weekly compensation, and when they settled their claims they received more money than the steam coal miners. Until 1939 the rate of certifications was higher in the anthracite region, but during 1943 and 1944 a majority of cases came from the steam coal region. Finally the proportion of totally disabled men was higher in the steam coal region.

Judging by the men's own account of their fitness for work, and their difficulty in obtaining jobs, the employment situation was far from satisfactory, although it improved during the war years. Older men evidently experienced greater difficulty in obtaining work than younger men, but a surprisingly large number of men in the advanced disease group felt fit for full-time employment and worked whenever jobs were available.

Mortality Rates.—Mortality rates in the two disease groups have already been mentioned, and the proportions of dead and surviving are shown in

TABLE 3

LIFE TABLES FOR MEN IN EARLY AND ADVANCED DISEASE GROUPS FROM THE DATE OF CERTIFICATION BY THE SILICOSIS MEDICAL BOARD, 1931–1944

Interval since certification in years	Disease Group					
	Early			Advanced		
	l_x	d_x	p_x	l_x	d_x	p_x
0*	1,000	15	0·985	1,000	71	0·929
½	985	17	0·983	929	89	0·904
1½	968	21	0·978	840	84	0·900
2½	947	18	0·981	756	82	0·892
3½	929	51	0·945	674	71	0·895
4½	878	46	0·948	603	73	0·879
5½	832	51	0·939	530	82	0·845
6½	781	62	0·920	448	53	0·882
7½	719	53	0·927	395	70	0·824
8½	666	46	0·930	325	48	0·853
9½	620	34	0·945	277	48	0·827
Total number of cases	1,741			1,694		
Number of deaths	208			768		

l_x = Number of men per 1,000 certifications alive at the beginning of each interval. d_x = Deaths per 1,000 certifications during next interval. p_x = Probability of surviving until beginning of next interval.

* The death rates shown in the first line are for a six months period and require to be doubled to make them comparable with those for subsequent periods.

* Where the odds against a difference in the data being due to chance are 95 per cent. or more (that is, not less than 19 to 1) this difference is described as significant.

Table 2. The total number of deaths discovered during the survey was 976. In 123 cases the cause of death was not ascertained, in 804 it was ascribed to the disease, and in 49 to other causes. Only 451 of the deaths had been reported to the Silicosis Medical Board.

To show more precisely the probability of survival in the two disease groups, life tables were constructed for the men traced during the preliminary survey. These are shown in Table 3. Each table covers the first ten years after certification, but since only 11 per cent. of the men in the early disease group and 25 per cent. in the advanced group had been certified for as long as ten years, the survival rates for the second quinquenium are based on fewer cases and are less reliable than those for the first five years. In addition, as the tables are based only on the traced men, they necessarily ignore 9 per cent. of the population. Since, however, the percentage of untraced cases in the two disease groups was identical, whereas the advanced disease group had a much higher mortality than the early group, it is unlikely that it is correlated with mortality. Therefore the omission of the untraced cases is unlikely to have upset the comparison between the two disease groups.

A rough interpolation in these tables shows that about 85 per cent. of men in the early disease group, and 57 per cent. in the advanced disease group, are likely to survive five years after leaving the mines. By the time ten years have elapsed, about 60 per cent. of men in the early and 25 per cent. in the advanced group, may still be alive.

In Chart 1 the survival rates are compared with those for males aged 50 years given in the 1931 English Life Table No. 10 (Registrar General Decennial Supplement). The comparison is not quite fair, because the latter is derived from males in every social class whereas all men with pneumoconiosis are included in Social Classes III and IV. Nevertheless the survival rate in the case of the men with pneumoconiosis is so much lower than in the other group that it is most unlikely that advancing age and the normal hazards of life were the only factors determining the number of deaths.

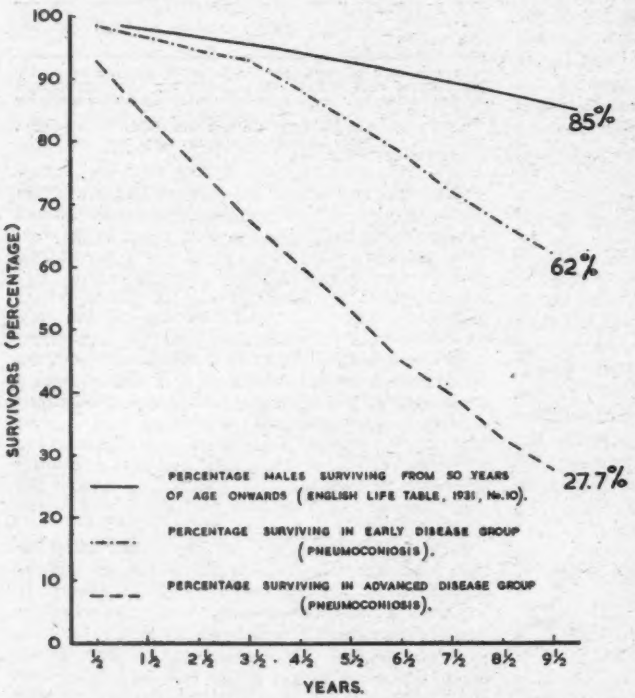

CHART 1.—Mortality after certification by Silicosis Medical Board: men traced in 1946 Survey. The early disease group comprises men certified as having reticulation or first-stage silicosis, the advanced disease group those with second- and third-stage silicosis.

Separate study of the anthracite and steam coal workers revealed certain differences in the survival rates in these two groups which at first sight suggested that the disease acquired by the anthracite miners followed the more benign course. Since this finding was at variance with the observations of Pancoast and Pendergrass (1931) and with other findings in this survey (see page 128) a more detailed investigation of the men from the two regions was made. This showed that the difference was confined to men with advanced disease, and when this group was separated into its two components it was found that the proportion of third-stage silicosis cases was higher in the steam coal sample. Since these men tended to die sooner than those classified as having second-stage silicosis (see Chart 2), the difference in mortality rates in the two regions need not be ascribed to any fundamental difference in the disease in the two parts of the coalfield.

Examination of Survivors.—It was originally intended to examine four hundred men in the early, and four

TABLE 4

1946 SURVEY : SURVIVORS TRACED AND SAMPLE EXAMINED : ANALYSIS BY DISEASE GROUP, AGE, AND DATE OF CERTIFICATION (SAMPLE FIGURES IN BRACKETS)

Age at certification in years	20–48		49 and over		Total
Date of certification	1931–9	1940–4	1931–9	1940–4	
Early disease group	187 (88)	671 (91)	149 (83)	526 (87)	1,533 (349)
Advanced disease group ..	158 (76)	257 (77)	197 (74)	314 (78)	926 (305)
Total	345 (164)	928 (168)	346 (157)	840 (165)	2,459 (654)

Method of sampling : one hundred cases were chosen at random from each of the third-order classes (*i.e.*, the cells shown in the table). The figures in brackets are the numbers actually examined.

hundred in the advanced disease group, and to choose the two samples so that the time factor and the age distribution were the same in both. This was done by dividing the available cases into eight groups (see Table 4), and taking a random sample of one hundred cases from each. However, owing to a considerable lapse rate, only 654 men were examined, of whom 349 were in the early, and 305 in the advanced disease group. The former included 171 men certified before 1940, and 178 certified between 1940 and 1944; the latter 150 and 155 respectively. The mean age at certification in the early group was 48·2 years, and in the advanced group 49·8 years.

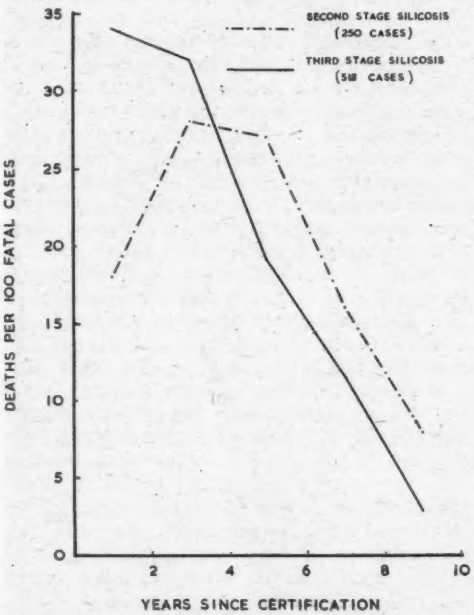

CHART 2.—Intervals between certification and death in advanced disease group : contrast between second- and third-stage silicosis. (1946 Survey.) The advanced disease group comprises men certified as having second- and third-stage silicosis.

Most of the men were examined as out patients, but a few were admitted to hospital. In every case a detailed history was taken, and this was followed by a clinical examination, which included a standard exercise test, measurement of the vital capacity and blood pressure, and urine examination. Special investigations included *x*-ray examination of the chest, and examination of the sputum and blood (hæmatocrit, erythrocyte sedimentation rate, and Wassermann reaction).

Employment History.—Before certification all the men had been employed underground, and over

TABLE 5

1946 SURVEY : EMPLOYMENT SINCE CERTIFICATION (BY DISEASE GROUP AND AGE AT CERTIFICATION)

Disease group[1]	Age at certification in years	Employment since certification			Total	
		Good[2]	Fair[3]	Nil		
		%	%	%	%	Number
Early	Under 50	65	29	6	100	223
	50 and over	29	29	42	100	126
	Total	52	29	19	100	349
Advanced	Under 50	56	22	22	100	167
	Over 50	17	27	56	100	138
	Total	38	24	38	100	305
Total	%	45	27	28	100	
	Number	299	174	181		654

(1). The early disease group consists of men certified as having either reticulation or first-stage silicosis, and the advanced disease group those certified as having second- or third-stage silicosis.
(2). Good employment = in work for over half the period between certification and follow-up.
(3). Fair employment = in work but for less than half the period between certification and follow-up.

95 per cent. had spent the greater part of the time at the coal face. About half the colliers had spent periods in hard ground (rock drilling) and a few had worked exclusively in rock. The shortest time spent underground was ten years, the longest over fifty years, but there was only a slight difference between the duration of dust exposure in the early and advanced disease groups; the average period being 29·6 years in the former and 30·9 years in the latter*.

After leaving the mines the employment rate was higher among younger men; and men under 50 years with advanced disease found employment more often than men over 50 years with early disease. Approximately one third of the men who obtained employment worked out of doors, one third indoors, and one third in mixed occupations. The proportion of men in the early and advanced disease groups was the same in all types of employment, but whilst 37 per cent. of outdoor workers were over 50 years of age at the time of certification, only 26 per cent. of indoor workers were in this age group.

Symptomatology.—According to the clinical histories obtained at the time of the follow-up, the disease appeared to be relatively benign and to pursue a slow course†, but there did not seem to be much permanent improvement after leaving the mine. Occasionally disease had been discovered before the patient was aware of symptoms, and it was clear that gross radiological changes were compatible with remarkably little disturbance of general health. However, most of the men complained of dyspnœa and cough, and both these symptoms persisted and frequently increased in severity after certification.

Dyspnœa usually preceded cough by several years, but as it was often slight in degree its presence was frequently ignored until some intercurrent infection or "breakdown" occurred. By the time of the follow-up several men who had continued to do a full day's work up to the time of certification, were unable to walk more than a few yards without becoming short of breath. The commonest causes of an aggravation of this symptom were: particular types of exertion to which the man was not accustomed, work which involved heavy lifting, and intercurrent illnesses.

* This close approximation corresponds to the similar age distribution of the men in the two disease groups. Had a random sample of men in the two groups been examined it is likely that there would have been a shorter length of exposure in men with early disease and a longer period in men with advanced disease, corresponding with the difference in average age at certification of the two disease groups (see Table 2).

† This may be an understatement, as the disease was probably less benign and had pursued a more rapid course in some of the men included in the original sample (for example, those who had died shortly after leaving the mines).

TABLE 6

1946 SURVEY: PERCENTAGE INCIDENCE AND SEVERITY OF SYMPTOMS IN 654 MEN WHO WERE MEDICALLY EXAMINED

Symptom	Incidence		Severity	
	Before certification %	After certification %	Worse after certification %	Improved after certification %
Dyspnœa ..	90	98	54	13
Cough	79	87	30	24
Asthenia ..	54	63	43	30
Loss of weight..	33	27	28	23
Acute respiratory illnesses	24	26	—	—
Chest pain ..	17	34	39	20
Hæmoptysis ..	6	8	—	—
Melanoptysis ..	1	14	—	—
Other [1] ..	10	33	24	10

(1). Other symptoms included giddiness, palpitations, vomiting, and headache.

Cough, though common, was not as a rule a distressing feature until the disease was well advanced. During the late stages, however, it was often associated with a particularly tenacious type of sputum, and efforts to expectorate this led to severe paroxysms of coughing and intense exhaustion. Hæmoptysis was recorded in 103 cases. This usually accompanied an acute respiratory illness but occasionally occurred without warning. Black sputum was the rule before certification, and this discoloration tended to persist for several months after leaving the mine. A particular type of black spit*, resembling an hæmoptysis both in the abruptness of its onset and in the copious amount of fluid expectorated, was recorded in 101 cases. This so-called "melanoptysis" usually occurred for the first time several years after leaving the mine, and was evidently a feature of the late stage of the disease. In two cases a melanoptysis occurred while the patient was in hospital, and serial radiographs showed a large cavity developing in the centre of an area of consolidation. In one of these patients the sputum was found after the event to contain tubercle bacilli, but in the other sputum tests remained persistently negative.

Most of the men who continued to work underground after dyspnœa had become severe experienced

* Copious black sputum is such a characteristic feature of coal-miners' pneumoconiosis that in early accounts the disease is often referred to as "black spit, or miners' melanosis" (Thomson, 1858).

TABLE 7

1946 SURVEY: RADIOLOGICAL PROGRESSION SINCE CERTIFICATION RELATED TO OTHER DATA

		Radiological progression [1]			Total	
		Nil %	Slight %	Marked %	%	Number
Disease group [2]	Early	47	23	30	100	349
	Advanced	26	24	50	100	305
Age when certified in years	Under 50	32	20	48	100	362
	50 and over	43	30	27	100	292
Interval since certification in years ..	Under 5	53	27	20	100	288
	5 and over	23	22	55	100	366
Total	%	37	24	39	100	
	Number	241	156	257		654

(1) In *no* case was any evidence of regression of the disease observed.
(2) The early disease group consists of men certified as having reticulation or first-stage silicosis, and the advanced disease group those certified with second- and third-stage silicosis.

either asthenia, loss of weight, or pain in the chest; and in several cases one or other of these symptoms first drew the patient's attention to his condition. Although leaving the mine often caused temporary relief of these symptoms, later they frequently became prominent features of the disease.

Acute respiratory illnesses, variously described as pneumonia, pleurisy, or acute bronchitis, were recorded in 272 cases. These usually occurred after the onset of other symptoms of pneumoconiosis, and recurrences after certification were common. The illness was sometimes accompanied by hæmoptysis, and several patients had been intensively investigated for tuberculosis, but with negative results. Occasionally symptoms suggested a spontaneous pneumothorax and in five cases radiological evidence of this was found.

A variety of other symptoms such as giddiness, palpitations, and vomiting was described, which became increasingly frequent after certification, and by the time five years had elapsed most of the men had noticed an appreciable deterioration in their general health. This downward trend was more conspicuous among men with advanced disease but was also common in the early disease group.

Radiological Findings.—When the Silicosis Medical Board *x*-ray films were compared with the ones taken at the time of the follow-up, changes were found to have occurred in the majority of cases. These invariably suggested further progression of the disease and, although a third of the cases showed no appreciable difference between the two radiographs, *no instance of spontaneous resolution of the disease after removal from the dust hazard was observed.* The commonest findings were an extension of shadows in both lung fields with an associated increase in emphysema, but either of these changes sometimes occurred alone, and sometimes only one lung was involved. Occasionally a large shadow seen in the first film was no longer visible in the second, but it was clear from the context that the "disappearance" was due to cavitation and not to resolution (see illustrations).

These apparently irreversible changes evidently occurred slowly, and only 47 per cent. of cases in which the interval was less than five years showed definite evidence of radiological progression, whereas 77 per cent. of those in which the interval was over five years showed increase of shadows in the second film. The frequency with which changes occurred was also intimately related to the stage of the disease at the time of certification, evidence of radiological progression being nearly half as common again in the advanced disease group as in the early group. Nevertheless 12 per cent. of cases of reticulation (a category first recognized in July, 1943) had developed new shadows in less than three years. Finally more younger men showed evidence of progression of the disease after exposure to dust had ceased.

The earliest stage of the disease included in the present series was represented by radiographs in which fine mottling was visible throughout both lung fields. This tended to obscure normal lung markings, and produced instead a characteristic circle-and-dot pattern which extended right out to the periphery. Accompanying this diffuse shadow, which closely resembles the annular and punctate mottling described by Caplan (1946) there was

almost always increase in the hilar shadows, and striæ radiating from the hila appeared to incorporate several small areas of coalescence.

At the other end of the scale were films in which there was such gross distortion of both lung fields that it was difficult to recognize familiar landmarks. Either the major part of both lung fields was obliterated by ill-defined shadows resembling bunches of cotton wool, or well-defined "cricket ball" or "angel wing" shadows alternated with areas of increased translucency. In the latter, elongated striæ were seen stretching from the large shadows to the diaphragm, mediastinum, and periphery of the lung fields, causing these to assume a most bizarre appearance. Frequently the hila appeared to be displaced or incorporated in larger shadows, and the trachea sharply kinked immediately above the clavicle. A central area of translucency within a massive shadow sometimes suggested the presence of a cavity, but unless this showed evidence of a fluid level it was difficult to distinguish from other translucent areas which were almost certainly due to emphysematous bullæ.

Every intermediate stage between these two extremes was represented, and there appeared to be little doubt that, after the diffuse shadow pattern was established, the disease progressed by the slow development of new areas of consolidation, which gradually coalesced and produced emphysematous changes in the surrounding lung tissue. These conglomerate shadows appeared in both lung fields, but the right lung was usually more heavily infiltrated than the left, and upper and mid zones more than lower zones; the right upper zone immediately below the clavicle appeared to be the site of election for the first "local" shadow, whilst the apices of both lungs often remained quite clear.

In each *x*-ray category and each sub-group (see footnote, page 121) there were cases in which progression of the disease had occurred within three years of certification, but even in the "third-stage silicosis" group there were cases in which the radiological appearances had remained unaltered for more than ten years. The findings as a whole suggested that the disease might become temporarily arrested at any stage; and evidently further extension of the shadows in one region could go hand in hand with compaction of pre-existing shadows and development of emphysema in another part of the lung. Although more cases in the advanced disease group showed signs of progression, it was impossible to decide from the appearance of the original film whether or not changes would be found in the follow-up plate.

Careful scrutiny of the films failed to reveal any difference between anthracite and steam coal miners, and the rate of progression was the same in both groups of workers. Neither the length of time spent underground nor the type of work done before certification appeared to influence the course of the disease after leaving the mine; but in each age group men who obtained outdoor work after certification did rather better than those who worked in factories (Table 8).

Tests of significance on the data given in Table 8 showed that when the two age groups were considered separately they did not provide undoubted evidence that the course of the disease had been affected by the type of employment. But when the joint probability was calculated, a statistically significant relationship was established between incidence of radiological progression and type of work done since leaving the mines; the disease showing less tendency to progress in outdoor workers than in factory operatives.

Clinical Findings.—By the time of the follow-up there were 145 men whose radiographs showed evidence of "mild" disease, 175 with "well-established" disease, 188 with "severe" disease, and 146 with "gross" disease*.

Most of the men in the mild disease group were found to have a normal physique, and although 90 per cent. of them complained of breathlessness on exertion, nearly half completed the exercise tolerance test without showing signs of distress, and one third had a vital capacity within normal limits†. Apart

* To obtain an indication of the stage of the disease at the time of the follow-up, the radiographs taken at this time were arranged in four groups. To avoid confusion with the *x*-ray classification used by the Silicosis Medical Board, and with the two disease groups used for selecting cases for examination, these four groups have been named as follows:

Category 1 (representing mild disease).—Not more than generalized reticulation with small areas of coalescence confined to one or two zones.

Category 2 (representing well-established disease).—Not less than the maximal appearances found in category 1 and not more than generalized reticulation with early emphysema and *either* widely scattered but small areas of coalescence, or larger areas confined to one or two zones.

Category 3 (representing severe disease).—Not less than the maximal appearances found in category 2 and not more than partial obliteration of the original reticulation by multiple areas of coalescence and emphysema.

Category 4 (representing gross disease).—Not less than the maximal appearances found in category 3 and including films in which the reticulation was completely obliterated by large areas of coalescence and emphysema.

When the films from the Silicosis Medical Board were also catalogued in this way it was found that 35 per cent. of the certification films and 22 per cent. of the follow-up films were in the mild disease group; while 6 per cent. of the certification films and 22 per cent. of the follow-up films were in the gross-disease group.

† For the exercise tolerance test a step 18 inches high was used. The subject placed, and kept, one foot on the step and raised his body to the erect position on the step twenty times in sixty seconds. Men who were too breathless to attempt or failed to complete this test were recorded as "severely dyspnœic," those who were still out of breath one minute after completing the test were recorded as "moderately dyspnœic," and those who did the test without undue distress were recorded as normal.

The vital capacity was measured on a simple spirometer and the best of three readings was taken. The result in each case was compared with the "expected" value from men of the same age and same sitting height (McMichael, 1945) and expressed as a percentage of the expected value.

TABLE 8

1946 SURVEY: EMPLOYMENT SINCE CERTIFICATION RELATED TO RADIOLOGICAL PROGRESSION AND ABSENCE FROM WORK OWING TO SICKNESS

Age at certification in years		Under 50		50 and over		Total	
Employment since certification		Outdoor %	Indoor %	Outdoor %	Indoor %	%	Number
Radiological progression since certification	Marked	39	49	16	29	37	111
	Slight	20	20	27	39	24	71
	Nil	41	31	57	32	39	114
Sickness absence from work	Long spells	16	28	13	33	23	68
	Short spells	36	37	38	39	37	109
	Nil	48	35	49	28	40	119
Total	%	100	100	100	100	100	
	Number	87	117	51	41		296 [1]

(1) A further 167 men obtained employment after leaving the mines, but as they had worked partly indoors and partly out of doors they have not been included. The interval since certification and the proportion of men in the early and advanced disease groups was the same in all three types of employment. Tests of significance: when the "marked progressors" and "non-progressors" were compared separately in the two age groups a gross chi squared (with two degrees of freedom) of 5·788 was obtained. Since both age groups showed deviations in the same direction the value of $\frac{1}{2}$ p is 0·03.

from a tendency to poor expansion and rather distant breath sounds, very few showed abnormal physical signs in the chest, but slight clubbing of the fingers was recorded in 12 per cent. of cases, and pale mucous membranes in 5 per cent.

The gross disease group included 43 per cent. of men in whom the physique was recorded as good; and 18 per cent. in which it was poor. Over 80 per cent. were observed to be unduly dyspnœic on attempting the exercise tolerance test, and nearly 100 per cent. had a sub-normal vital capacity. The tendency to poor chest expansion was not much more marked than in the mild disease group, but many more cases showed other physical signs in the chest. Compared with the radiological findings these were slight and indefinite, but either marked flattening of the chest below the clavicles, hyper-resonance over the bases, or an unusual variation

TABLE 9

1946 SURVEY: CLINICAL AND RADIOLOGICAL FINDINGS AT TIME OF FOLLOW-UP

Clinical findings		Radiological findings [1]				Total	
		Mild %	Well-established %	Severe %	Gross %	%	Number
General condition	Good	85	78	64	43	68	442
	Fair	14	20	29	39	25	168
	Poor	1	2	7	18	7	44
Objective dyspnœa [2]	Nil	47	38	32	15	33	219
	Moderate	30	32	31	25	30	193
	Severe	23	30	37	60	37	242
Vital capacity [3]	Over 90%	36	19	15	2	18	117
	70–90%	43	50	41	23	40	259
	Under 70%	21	31	44	75	42	278
Chest expansion	2–3 in.	22	22	18	7	17	112
	1–2 in.	70	68	70	73	72	470
	Under 1 in.	8	10	12	20	11	72
Total	%	100	100	100	100	100	654
	Number	145	175	188	146		

(1) For the definition of the *x*-ray categories shown in this table (see footnote on p. 128).
(2) Objective dyspnœa was classified as nil, moderate, or severe, on the results of a standard exercise tolerance test (see footnote on p. 128).
(3) The vital capacity is expressed as a percentage of normal (see footnote on p. 128).

TABLE 10

1946 SURVEY: RESULTS OF SPUTUM TESTS RELATED TO OTHER FINDINGS

		Sputum [1]	
Number of cases		Positive	Negative
		17	472
Interval since certification in years	Under 5	11	245
	5 and over	6	227
General condition	Worse	14	290
	No change or improved	3	182
Dyspnœa (subjective)	Worse	9	255
	No change or improved	8	217
Change in weight	Less	12	147
	Stationary or gain	5	325
Radiological progression	None	2	179
	Progression	15	293
E.S.R. mm. per hr. (Wintrobe)	0–9	2	203
	10–60	15	269

(1) Sputa from 489 men were examined for tubercle bacilli; 89 men had no sputum and 42 men with sputum were not tested.

in intensity of the breath sounds over adjacent areas of the lung, were recorded in nearly 100 per cent. of cases and in over 70 per cent. adventitious sounds were heard. Clubbing of the fingers was observed in one third of the cases, and pale mucous membranes in 15 per cent. Albuminuria was recorded in twenty cases, but peripheral œdema (one case) and cyanosis (two) were extremely rare.

A majority of cases (56 per cent.) bridged the gap between mild and gross disease. Two thirds of these men were found to be dyspnœic on exertion and over 80 per cent. had a subnormal vital capacity. On the other hand the physique was good in about 70 per cent. of cases and fair in 25 per cent. Despite this higher level of general physique, abnormal chest signs, clubbing of the fingers, and albuminuria were almost as common as in the gross disease group.

Incidence of "Open" Tuberculosis.—Examination of the sputum is not part of the routine procedure of the Silicosis Medical Board, but most men who have a productive cough are investigated elsewhere for tuberculosis. The present series included 401 men who had had their sputum tested after leaving the mines; but in only two cases were tubercle bacilli detected. One of these patients had a pleural effusion, and although this had resolved by the time of the follow-up (nearly four years later), other shadows in the radiograph had increased, and he was a very ill man. There appeared to be a large cavity in the left lung and the sputum was found to be still heavily infected with tubercle bacilli. In the second case the original film showed generalized reticulation with a small area of coalescence in the right upper zone. This patient's only symptom was cough, which ceased after he left the mine, and when he was seen three years later he declared that he was feeling quite well. Clinical examination revealed no abnormal physical signs, the sputum was negative, and there was no appreciable difference between the findings in the two radiographs.

During the follow-up it was found that 89 men had no cough, 34 had cough but no sputum, and 531 had a productive cough. Only 42 men failed to return the sputum outfit supplied at the time of the medical examination, and in 489 cases a specimen was examined for tubercle bacilli. Nineteen of these men were admitted to hospital within six months of being examined, and in these cases the sputum tests were repeated on several occasions.

Method.—In every case at least 10 ml. of sputum was concentrated by Jungmann's Method (Jungmann, 1938; Nassau, 1942) and a direct smear was made from the deposit. Heavy inocula were seeded on to eight slopes of Lowenstein-Jensen's medium and eight of Dorset's egg (unglycerinated), and the residue from every fourth specimen was inoculated into a guinea-pig. If either direct smear or culture suggested the presence of tubercle bacilli, the finding was confirmed by guinea-pig inoculation.

Results.—Tubercle bacilli were isolated from seventeen cases. This represents 2·6 per cent. of all cases, 3·2 per cent. of cases with sputum, and 3·5 per cent. of the specimens examined. In two cases a suspicious finding on culture was not confirmed on animal inoculation, and one specimen which yielded a negative culture produced a positive result when injected into a guinea-pig. In only one of the nineteen patients admitted to hospital was the original finding reversed. This man had a negative sputum at the time of the follow-up and again when admitted to hospital four months later. While in the ward he had a melanoptysis and a cavity developed in the right lung; on four subsequent examinations his sputum was found to contain tubercle bacilli.

One patient with positive sputum was found to have a pleural effusion in addition to evidence of advanced pneumoconiosis, but in the remainder the radiological findings were indistinguishable from those found in negative cases. The group as a whole, however, contained a disproportionately large number of "ill" men, most of whom had

developed new shadows after certification and were in an advanced stage of pneumoconiosis. The erythrocyte sedimentation rate (E.S.R.) was usually raised, and the general impression was that these men were suffering from a more rapidly progressive type of disease than men with no bacteriological evidence of tuberculosis (see Table 10).

To this rule, however, there were a few interesting exceptions. For instance one patient with tuberculosis was practically symptomless and showed no signs of radiological progression over a period of four years, and three had " held their own " for more than eight years before their health began to fail. Finally two patients, in spite of being very ill men and showing signs of rapid progression of the disease, had erythrocyte sedimentation rates of less than 7 mm. per hour (Wintrobe).

Hæmatology.—in 641 cases the erythrocyte sedimentation rate and corpuscular volume (hæmatocrit) were estimated by methods described by Wintrobe and Landsberg (1935). The former ranged from less than one to over 60 mm. per hour, with an average value of 15·7 mm. per hour*.

At first there appeared to be little in common between radiological findings and erythrocyte sedimentation rate, as several men with grossly abnormal radiographs showed normal values, and *vice versa*. When, however, the results were finally analysed, it was found that there was a definite tendency for the sedimentation rate to be higher in men with gross than in those with mild disease, while the distribution of sedimentation rate values in the intermediate *x*-ray categories lay between these two extremes.

More striking, however, was the association between " radiological progression " and raised erythrocyte sedimentation rate (Table 13). Where the interval between certification and follow-up was less than five years, the sedimentation rate was 10 mm. or over per hour in 86 per cent. of cases in which marked progression had occurred, in 81 per cent. of those showing slight progression, and in 42 per cent. in whom no radiological changes were observed. Where the interval was over five years the rate was 10 mm. or over per hour in 67 per cent. of the cases showing marked progression, in 64 per cent. with slight progression, and in 15 per cent. with no radiological changes.

In both long- and short-interval groups the difference between " progressors " and " non-progressors " was statistically significant ; the two extremes being represented on the one hand by cases in which marked radiological changes had occurred within five years of the erythrocyte sedimentation rate being estimated, and on the other by cases in which the disease had remained stationary for over five years.

* According to Wintrobe and Landsberg the average erythrocyte sedimentation rate for healthy adult males is 3·7 mm. per hour (standard error, ±0·16).

TABLE 11

1946 SURVEY : ERYTHROCYTE SEDIMENTATION RATES

Interval since certification in years	Radiological progression	Number of cases	Mean E.S.R. in mm. per hr. (Wintrobe)	Standard deviation
Under 5	Nil	150	12·0	11·1
	Slight	75	20·6	12·4
	Marked	58	27·3	14·1
5 and over	Nil	84	6·7	6·4
	Slight	77	13·5	10·5
	Marked	197	17·9	13·2
Total		641[1]	15·7	13·1
Cases with tubercle bacilli in the sputum[2]		17	29·5	14·9

(1) In thirteen cases the erythrocyte sedimentation rates were not estimated.
(2) These cases are included in the main body of the table.

The corpuscular volume, as determined from hæmatocrit readings, ranged from 23 to 55 per cent., with an average value of 39·5 per cent. Since the normal range for healthy adult males is 41 to 52·5 per cent., with an average of 46·8 per cent. (Price-Jones and others, 1935), the findings showed that the group as a whole was anæmic.

This tendency to anæmia was fairly closely related to stage of the disease as shown by radiological findings (Table 12). This being so, there was also an association between low hæmatocrit readings and raised sedimentation rates, but further investigation of this relationship indicated that this could not explain the general increase in the sedimentation rate.

Discussion

It is abundantly clear from the foregoing account that pneumoconiosis of coal-miners frequently continues to progress after exposure to dust ceases, but since no comparable survey of men who continued to work underground has yet been made, it is impossible to say how much the course of the disease was affected by change in environment. To judge from the general sequence of events and the clinical histories—which suggested that men with advanced disease may continue working underground for long periods without experiencing disabling symptoms—it is unlikely that leaving the mine was more than slightly beneficial.

The apparent absence of any relationship between time spent underground and progression of the

TABLE 12

1946 SURVEY: ERYTHROCYTE SEDIMENTATION RATE AND HÆMATOCRIT READINGS RELATED TO RADIOLOGICAL FINDINGS AT THE TIME OF THE FOLLOW-UP

		Radiological findings [1]				Total	
		Mild %	Well-established %	Severe %	Gross %	%	Number
E.S.R. mm. per hr. (Wintrobe)	0–9	66	44	37	27	43	275
	10–19	27	30	28	27	28	179
	20–61	7	26	35	46	29	187
Hæmatocrit (%)	41–55	57	42	30	37	40	259
	36–40	37	46	50	47	46	291
	23–35	6	12	20	16	14	91
Total	%	100	100	100	100	100	
	Number	139	171	185	146		641 [2]

(1) For the definition of the *x*-ray categories shown in this table see footnote on p. 128.
(2) In thirteen cases the erythrocyte sedimentation rate and hæmatocrit were not estimated.

disease after leaving the mine suggests that some factor other than dust is necessary if the disease is to run its full course. The radiological appearances, raised sedimentation rates, and tendency to anæmia* all point to infection superimposed on a widespread pulmonary fibrosis; while the fact that areas of coalescence frequently originated in the upper lobe of the right lung, and that the radiological findings in cases with open tuberculosis were indistinguishable from the others, suggest that, despite the low incidence of open tuberculosis, the infective agent may be the tubercle bacillus.

Autopsy studies have produced convincing evidence that tuberculosis plays a major role in the late stages of coal-miners' pneumoconiosis. But just as in the present study of living men there was a gross disparity between incidence of open tuberculosis (2·5 per cent.) and radiological evidence of progression of the disease (63 per cent.), so also has it often proved impossible to obtain bacteriological confirmation of tuberculosis in fatal cases with gross pathological changes in the lungs (Rogers, 1946: Gough, 1946). Nevertheless, despite the absence of this final piece of evidence, pathologists believe that the late lesions are frequently those of a curiously modified form of tuberculosis (Cummins and Sladden, 1930; Belt and Ferris, 1942).

The disparity between bacteriological findings and clinical and pathological manifestations suggests either that the tuberculous infection has been so

* See also Tortori-Donati (1947), who found a tendency to anæmia and a raised erythrocyte sedimentation rate in coal-miners with advanced pneumoconiosis.

TABLE 13

1946 SURVEY: ERYTHROCYTE SEDIMENTATION RATE RELATED TO RADIOLOGICAL PROGRESSION SINCE CERTIFICATION

	E.S.R. mm./hr.	Radiological progression			Total	
		Nil %	Slight %	Marked %	%	Number
Interval since certification less than 5 years	0–9	58	19	14	39	110
	10–19	25	35	21	26	75
	20–61	17	46	65	35	98
	Total %	100	100	100	100	
	Total Number	150	75	58		283
Interval since certification over 5 years	0–9	85	36	33	46	165
	10–19	11	38	33	29	104
	20–61	4	26	34	25	89
	Total %	100	100	100	100	
	Total Number	84	77	197		358

profoundly modified by the co-existent pulmonary fibrosis that the infecting organism is no longer identifiable, or that other infective agents may produce chronic lesions which are morphologically indistinguishable from silico-tuberculosis. It is outside the scope of the present enquiry to determine which of these alternatives is correct, but the low incidence of open tuberculosis and the fact that by the time this develops patients are usually unfit for work, indicate that it is fairly safe for men with pneumoconiosis to be employed alongside other workers. An even greater degree of safety would be achieved if all men with pneumoconiosis underwent regular medical examination.

Nearly all the men who were examined during the follow-up were more breathless than ill, and it would appear that, in the absence of clinically recognizable tuberculosis, pneumoconiosis not only causes remarkably little disturbance of the general health but also often pursues a very slow course. It is likely, therefore, that a majority of men certified by the Silicosis Medical Board will remain fit for full-time employment for several years after leaving the mines, only the type of work that they can do is likely to be limited by the amount of exertion required.

The observation that men who obtained outdoor employment after certification did better than those who worked indoors may be due to selective recruitment. But the even distribution of men in the early and advanced disease groups in the two types of employment is an argument against such an hypothesis, and the possibility that the working environment had some effect on the course of the disease must be considered.

Inasmuch as the late effects of pneumoconiosis may be due to infection superimposed on the original dust disease, the difference between indoor and outdoor workers may be due to the fact that the latter were less prone to contract respiratory infections from fellow workers. On the other hand it is equally possible that either the need to take more strenuous exercise, or the absence of excessive humidity or dust in the working environment, or less exposure to abrupt changes of temperature, may have had a relatively favourable effect on the outdoor workers. Clearly more work must be done before attempting to define optimal conditions of employment but, crude as it is, the observed difference between the indoor and outdoor workers suggests that the successful application of certain measures designed to reduce the incidence of respiratory infections might reduce the tendency to progression. As they exist at present most outdoor jobs are too heavy for men with pneumoconiosis to tackle, so that our findings should *not* be taken to suggest that these are always suitable. Rather, attention should be directed to improving factory conditions so that the risk of cross infection is reduced to a minimum.

Since the survey necessarily covered only two dates in each case, it is possible to draw only tentative conclusions regarding the erythrocyte sedimentation rate findings. The comparatively large number of normal values observed in men who had left the pits for more than five years supports the general impression gained from examination of the radiographs; namely that the disease may become temporarily arrested at any stage. On the other hand the high proportion of raised sedimentation rates among men who were observed after a short interval and showed no radiological evidence of progression of the disease, suggests that a rise in sedimentation rate may precede detectable changes in serial radiographs, and may thus provide a valuable indication of the immediate prognosis.

It is generally thought that emphysema causes an increase in the number of erythrocytes circulating in the blood stream, but none of the men examined had polycythæmia and many were definitely anæmic. As already suggested, this tendency to anæmia may be due to intercurrent infection; but it is possible that the whole subject of emphysema and polycythæmia needs reinvestigation.

Summary

1. Nearly 3,500 miners who contracted pneumoconiosis while working in the anthracite and steam coal pits of South Wales were followed up after they had been away from the mines from two to fifteen years.

2. The subsequent mortality rates of men who left the mines during the "early" stage of pneumoconiosis were higher than normal. Those who did not leave underground work until the disease had reached an "advanced" stage had even higher mortality rates after leaving the pit.

3. Findings in respect of 654 men who were examined are described. These show that the disease frequently continues to progress after removal from the dust hazard, and suggest that the late results are due to infection superimposed on generalized pulmonary fibrosis. This progression of the disease after leaving the mine was rather more frequent in younger men, and somewhat less frequent among men who worked entirely out of doors during this period.

4. The disease in its early stages is often symptomless and even in late stages dyspnœa on exertion may be the sole manifestation. In men with advanced disease a particular type of black spit may occur

which is associated with breakdown of large areas of diseased lung tissue.

5. The overall incidence of open tuberculosis was less than 3 per cent., but although these men were usually much less fit than the others, the investigation revealed no specific criteria other than sputum examination whereby "tuberculous" and "non-tuberculous" cases may be distinguished.

6. In the absence of tuberculosis the disease frequently pursues a slow course and, apart from dyspnœa, produces remarkably little disturbance in general health despite gross radiological changes.

7. Progression of the disease is often accompanied by raised erythrocyte sedimentation rate and periods of arrest by normal sedimentation rate.

8. Early stages of the disease are not associated with any conspicuous alteration in corpuscular volume, but in more advanced stages anæmia is common.

A survey of this magnitude could not have been undertaken without the help of numerous people, many of whom it is impossible to mention by name. We would like particularly to thank Dr. Charles Sutherland, Chief Medical Officer of the Silicosis Medical Board, and his colleagues Dr. Keating and Dr. McVittie, who kindly allowed us access to all the records of this department and gave us much helpful advice. We are also indebted to the Ministry of Fuel and Power for compiling all the "Mines Lists," to the South Wales Miners Federation for organizing a large part of the preliminary survey, to the Oxford Bureau of Health and Sickness Records for sorting all the records, and to Miss Clarke of Ilfords' for providing the illustrations. The Cardiff Royal Infirmary should also be thanked for the radiographs. A large amount of statistical work was involved both in planning the experiment and checking the results, and without the assistance of Professor Bradford Hill, Dr. Russell, and Mr. Ian Sutherland the survey could not have been made. Finally we would like to thank Dr. Charles Fletcher, Director of the Pneumoconiosis Research Unit, who was responsible for initiating the investigation and provided us with invaluable help and criticism at every stage.

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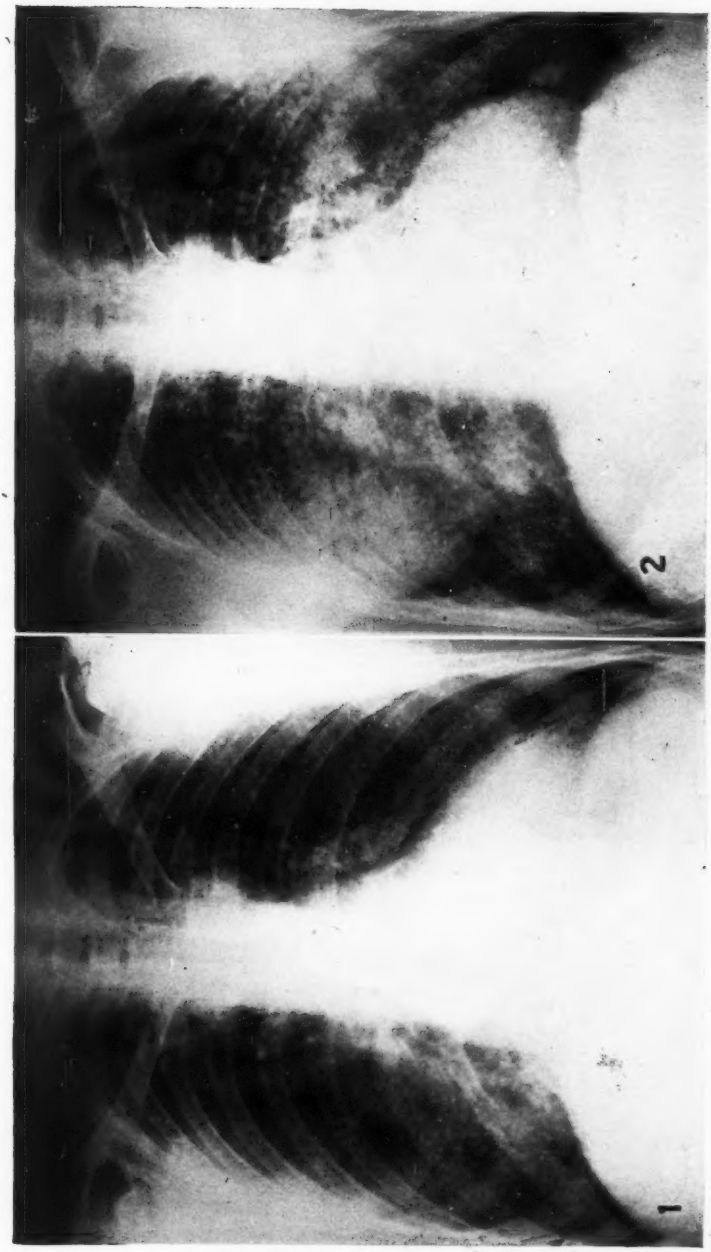

FIGS. 1 and 2.—Steam coal rockworker for sixteen years. Certified in 1937 (first-stage silicosis) at the age of 47. The follow-up nine years after certification showed the general condition to be good; there was no objective dyspnœa but slight clubbing of the fingers, and no abnormal chest signs. Chest expansion was 2 inches, vital capacity 66 per cent., E.S.R. 8 mm. per hour, hæmatocrit 39 per cent., and the sputum negative.

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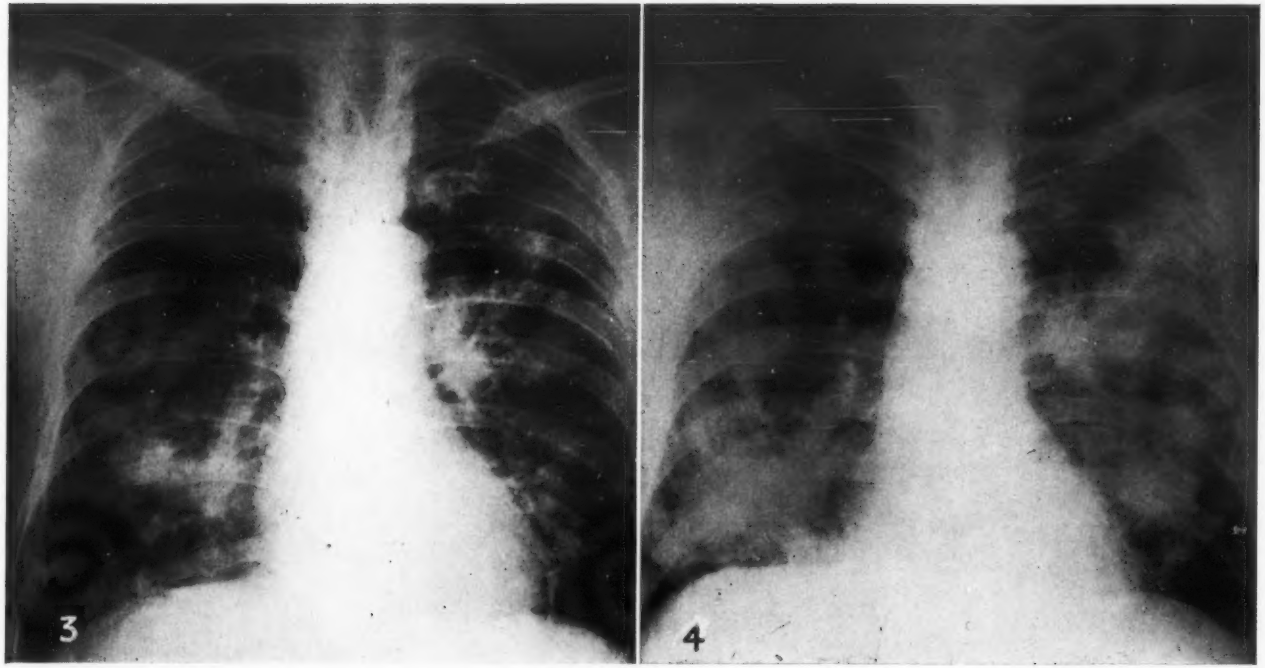
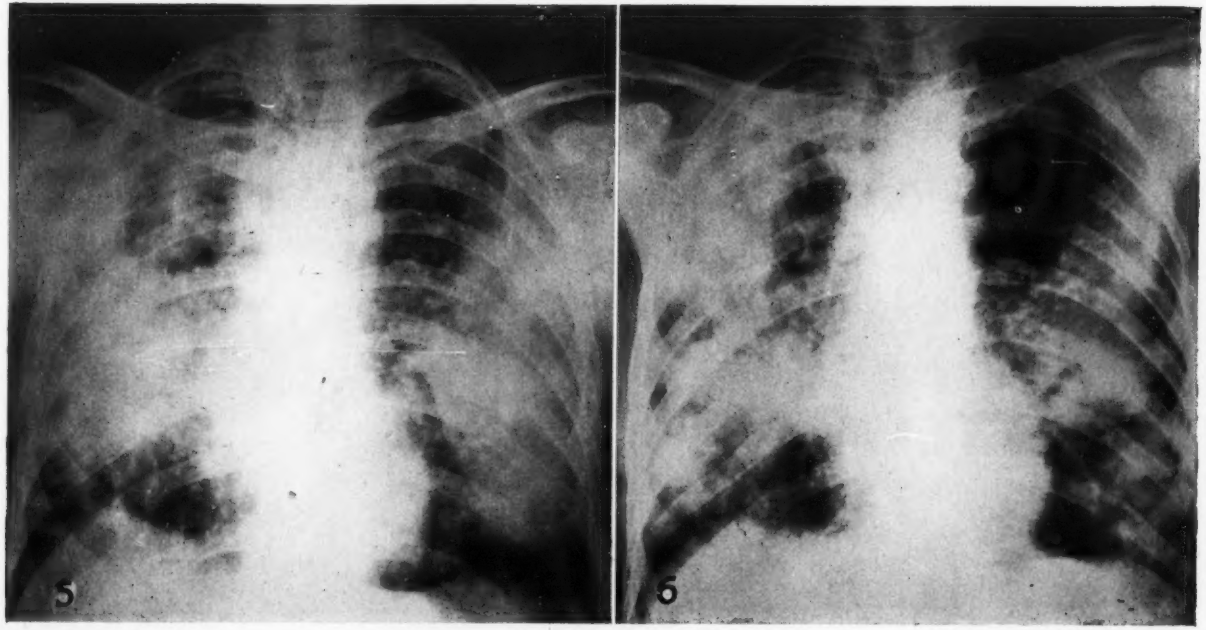
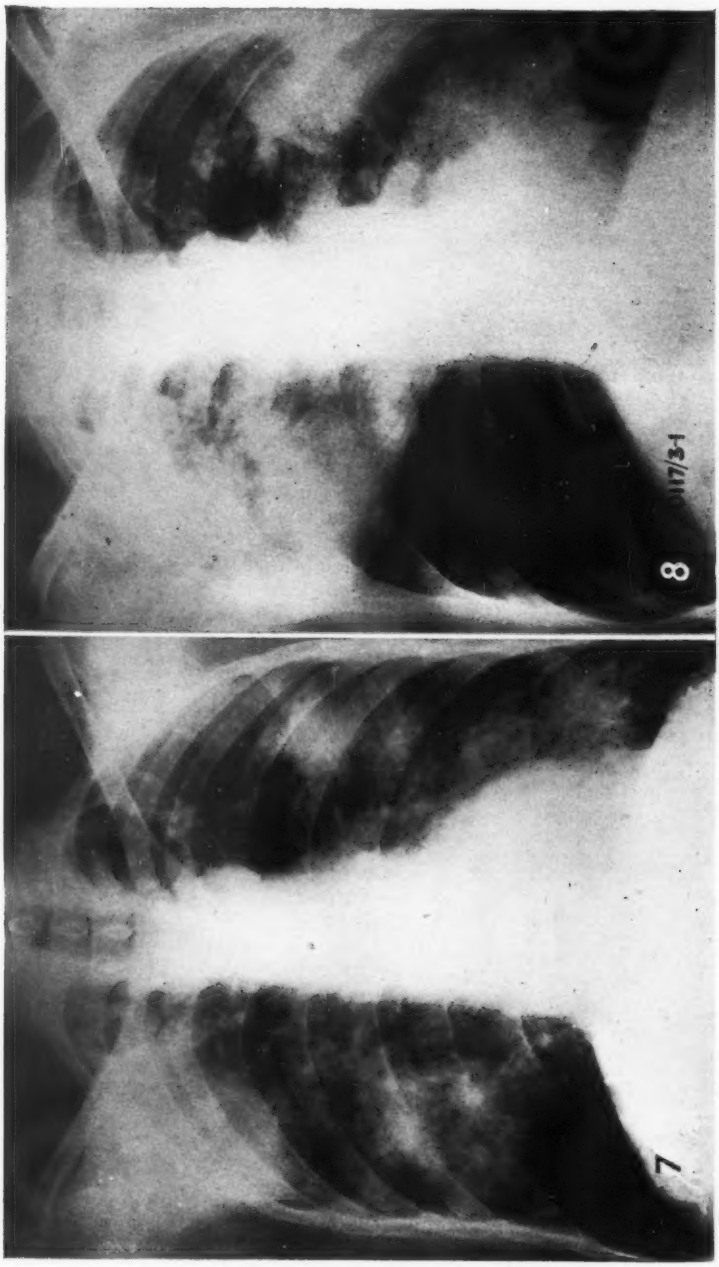


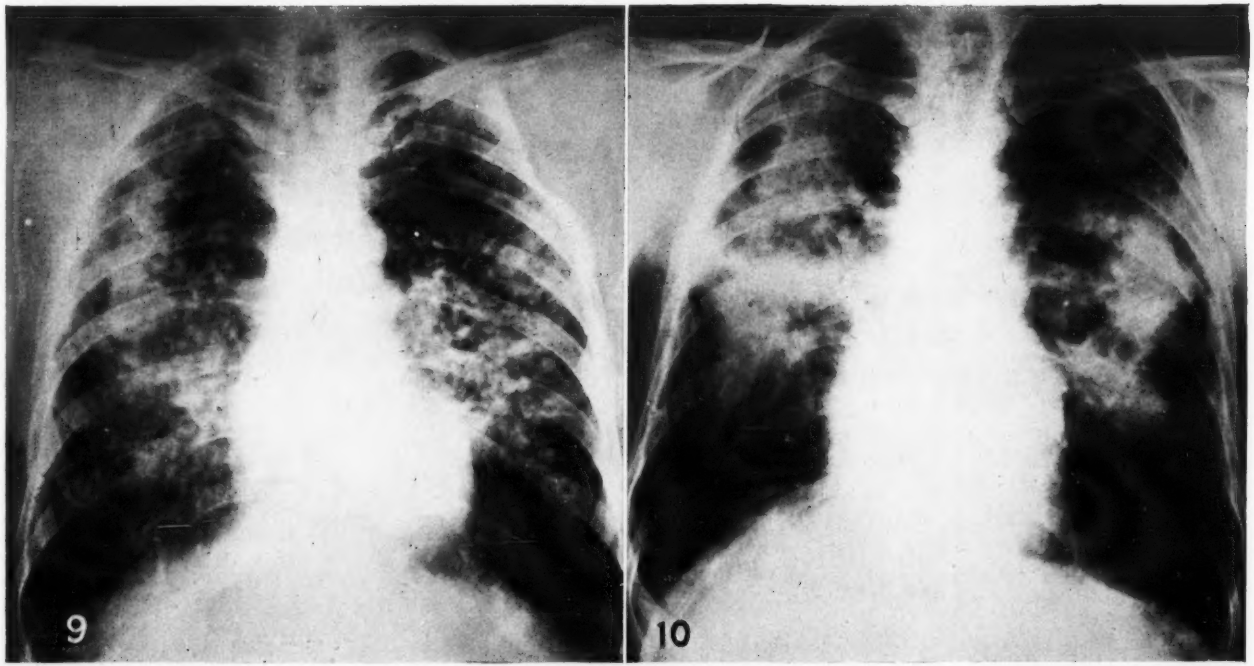
FIGS. 3 and 4.—Anthracite collier for twenty-three years. Certified in 1943 (second-stage silicosis) at the age of 42. After leaving the mine this patient had pneumonia with melanoptysis. A follow-up three years after certification showed the general condition to be good ; there was moderate dyspnœa but no chest signs, and the chest expansion was 1¾ inches. The vital capacity was 73 per cent., the E.S.R. 52 mm. per hour, the hæmatocrit 36 per cent., and the sputum negative.



FIGS. 5 and 6.—Steam coal collier for twenty-two years. Certified in 1940 (third-stage silicosis) at the age of 38. A follow-up six years after certification showed the general condition to be fair. He was underweight, and had tachycardia and focal signs at the right base. Chest expansion was ¾ inch, vital capacity 42 per cent., E.S.R. 42 mm. per hour, hæmatocrit 37 per cent., and the sputum negative.



FIGS. 7 and 8.—Steam coal collier for twenty-three years. Certified in 1942 (second-stage silicosis) at the age of 43. This patient had pleurisy in 1945. A follow-up four years after certification showed the general condition to be fair and the nutrition poor; there was severe dyspnœa, hyper-resonance, and prolonged expiration, and the chest expansion was 1 inch. Vital capacity was 50 per cent., E.S.R. 31 mm. per hour, and hæmatocrit 40 per cent. There was no sputum.



FIGS. 9 and 10.—Steam coal collier for twenty-five years. Certified in 1940 (second-stage silicosis) at the age of 41. This patient had occasional hæmoptyses between 1944 and 1946, and pleurisy in 1945. A follow-up six years after certification showed the general condition and nutrition to be poor; there was severe dyspnœa, marked clubbing, and focal signs in the right upper lobe. Chest expansion was 1 inch, vital capacity 39 per cent., E.S.R. 3 mm. per hour, hæmatocrit 36 per cent., and the sputum positive. His wife died of tuberculosis in 1945. (A normal E.S.R. with positive sputum was an exceptional finding; see p. 130.)

FIGS. 11 and 12.—Anthracite collier and haulier for twenty-eight years. Certified in 1937 (first-stage silicosis) at the age of 42. He had pleurisy in 1941. A follow-up nine years after certification showed the general condition to be fair, but there was severe dyspnœa and hyper-resonance. Chest expansion was 1½ inches, vital capacity 76 per cent., E.S.R. 2 mm. per hour, hæmatocrit 41 per cent., and the sputum negative. He was admitted to hospital with melanoptysis. A repeat radiograph showed a fluid level cavity and repeated tests of sputum gave negative results.

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THE HEALTH OF PLUMBAGO WORKERS IN CEYLON

BY

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From the Ceylon Medical Service

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Introduction

In the year 1945 the wages board for the plumbago trade directed the Ceylon Commissioner of Labour to hold an inquiry with a view to determining the period of work which a plumbago miner could perform without undue physical distress, especially with regard to: (1) the maximum period of continuous work an underground miner can reasonably be expected to perform in a mine of a depth of (*a*) less than 300 feet, (*b*) 300 feet and over; (2)

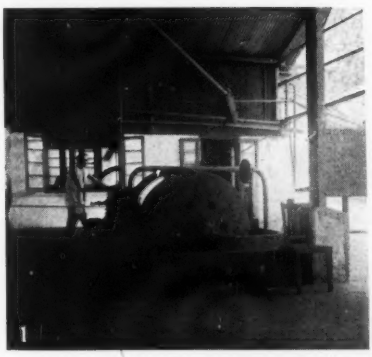

FIG. 1.—Mechanical windlass.

FIG. 2.—Trolleyways and galleries well lit with electricity, 500 feet below the ground level at Kahatagaha mines.

FIG. 3.—Plumbago miners at work in Kahatagaha mines, 800 feet below the surface. Note one miner carrying a coconut oil lamp and the height of the working galleries.

FIG. 4.—Plumbago collections are carried in trolleys to the curing sheds, Kahatagaha mines.

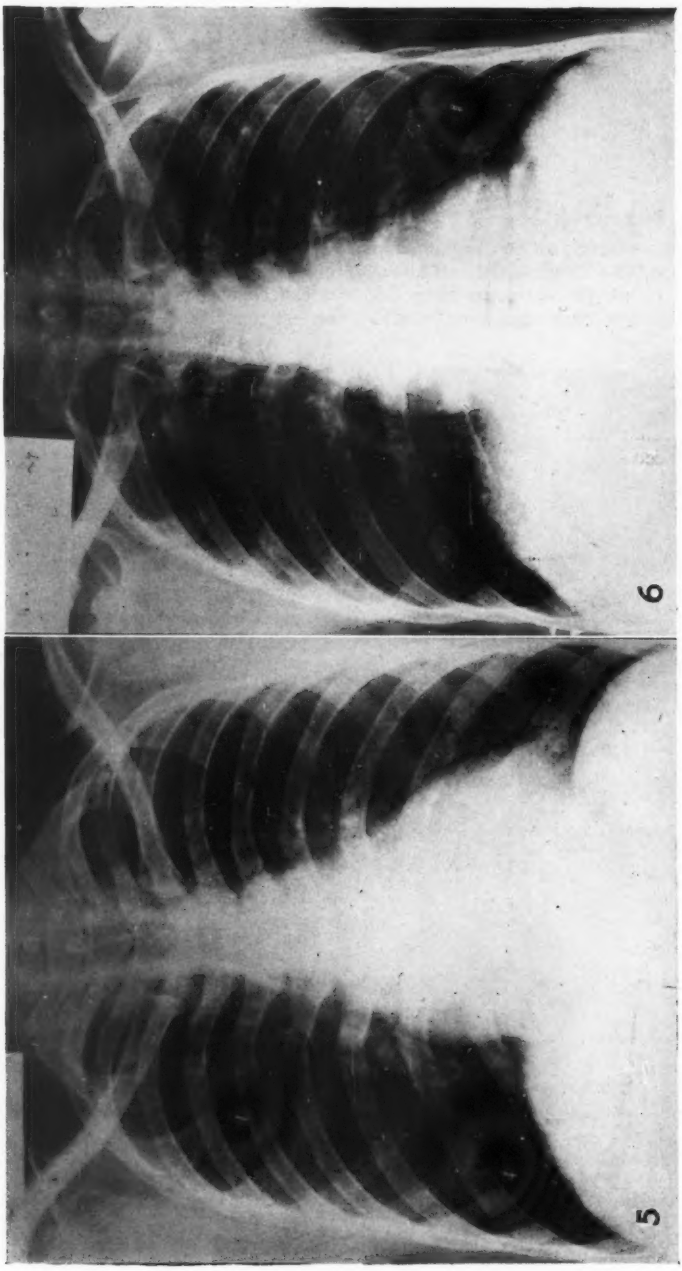

FIG. 6.—A man, aged 38, for twenty years worked as an underground plumbago miner. The radiograph shows diffuse fine nodulation.

FIG. 5.—A man, aged 42, for thirty years worked as an underground plumbago miner. The radiograph shows diffuse fine nodulation.

whether any work done in excess of the minimum period will be injurious to the health of the workers.

For various reasons, both technical and administrative, it was not possible to carry out the investigation till the middle of 1947, and the opportunity was taken at the same time to carry out this general survey relating to the health of plumbago workers.

Graphite, or plumbago, is a natural carbon, more or less pure, found in a crystallized state, or sometimes in brilliant amorphous masses which break easily. It is greyish black or steel blue in colour. Its presence in Ceylon has been known for a long time. Robert Knox, in 1681, mentions the existence of plumbago mines. The last Sinhalese King of Kandy in the very early eighties is said to have explored the possibilities of plumbago mining in Kegalle area as a method of increasing the State revenue. In 1825 the first known shipment was consigned to Mr. Joseph Dixon, founder of the great American Crucible Company; and in 1831 plumbago was included in the list of articles liable for export duty.

For the last hundred years Ceylon has been the principal supplier of superior-grade plumbago, which is the most valuable mineral asset of the island. Owing to its chemical purity and its perfect crystallization and physical structure, Ceylon plumbago is considered indispensable for the manufacture of crucibles for metallurgical use, the most important industrial application of the mineral. It is also used for paints, pencils, and lubricants and in the electro-carbon industries. The fluctuating condition of this industry is clearly recorded by Ceylon export statistics. From nearly 100 tons in 1834, export rose to nearly 31,000 tons in 1899. The plumbago industry reached its zenith in that year, when it brought into the country nearly 22,000,000 rupees, and established the fortunes of many Sinhalese business families. Since then the annual average export had varied from 10,000 to 20,000 tons, and the industry has employed large numbers of persons.

Geology

In Ceylon, plumbago occurs disseminated in the schists and marbles of Khondalite series, and also as vein deposits. It is the vein deposits that mainly provide the plumbago of commerce. Vein deposits comprise: (1) fissures filled with plumbago alone, either parallel or transverse to the foliation of the gneisses; (2) pegmatite veins, in which plumbago plays the part of an accessory mineral; (3) lenticular segregation in a highly sheared acid garnetiferous gneiss.

The three types of deposit are distinct morphologically only. They may occur in the same mine, and one form may graduate into another. Consequently the workable deposits of plumbago and the important mines are situated in well-defined belts following the strike of the gneisses. The belts are less than a mile in width, but they extend several miles along the strike.

Though plumbago is mined in various parts of the island, in its south-west quadrant the most important mining areas are: (1) the Ragedera, Maduragoda, Ruanwella area; (2) Pasdum Korale and Raigam Korale; (3) Galle and Matara districts. Three of the largest plumbago mines in the world, Kahatagaha mines, Kolongaha mines, and Bogala mines, are situated in the first-mentioned area. There are innumerable so-called plumbago pits but very few of them are proper mines. In the year 1941 there were over 2,000 pits, and most of them were of a speculative character of short working period.

Method of Mining

Whenever an outcrop of plumbago is found on the surface, the procedure is to follow the vein up to the rock. If it is by the side of a hill, earth is removed by what is called strip or open pit method, and the plumbago vein in the rock is exposed. In other places a trial shaft varying in size, usually 8 ft. × 8 ft., is sunk through the soft shale and earth formation, following the vertical vein until it strikes the solid rock. This portion of the shaft necessitates timbering, which is usually done by fixing long planks against the sides of the shaft, supported by transverse quarterings. After the solid rock is reached a tunnel is driven at right angles from the shaft in the direction of the plumbago vein. This tunnel ends in a small platform, from which the second shaft is sunk to a lower level. In this manner several shafts are driven, extending to total depths varying from 800 to 1,700 ft. In the lower levels tunnels are driven in the rock from a shaft in almost any direction indicating a vein of plumbago.

In the vicinity of the plumbago vein, solid rock is now blasted by drilling holes by hand to depths varying from 1 ft. to 4 ft. and then by firing them with blasting powder or dynamite charges.

After the blasting operations are completed and sufficient time is allowed for the fumes to clear away, usually about six hours, workers go down the shaft and tunnels, either by mechanical lifts (provided only in the Bogala mines) or ladderways, to the place where blasting operations were carried out. Here they break the plumbago-bearing rock to transportable sizes. Pieces of plumbago and plumbago-bearing rocks are transported on trolleys to the foot of the nearest shaft, where barrels drawn by a windlass provides the means of hoisting to the next level, and so on to the level at which the lift operates. From here a trolley filled with plumbago is taken up in the lift to the surface, where the trolley is directed on rails to curing yards. Except in two or three mechanized mines, haulage of plumbago from the mining head to the surface is by very crude methods, manually along ladderways.

Partial curing is performed at the mines by removal of gross pieces of attached rock and by the washing away of sand and mud. Plumbago is then transported to Colombo curing sheds. Here, after a preliminary selection by expert women workers, it is given a final curing and is then graded. For this purpose both manual labour and machinery are used. Larger blocks of graphite are reduced to the required size by wooden hammers, and stones are picked out by women workers. A sifting machine grades the plumbago into hard large lumps, ordinary lumps, chips, dust, and flying dust. Finally it is packed in barrels ready for export.

Number of Persons Employed

It is difficult to estimate the number of persons employed in the industry, as the numbers vary with the number of mines worked each year, which entirely depends on the price and prosperity of the export market. Except in the case of about half a dozen well-organized mines, which are mechanized, there is no regular employment for miners. Internal springs and monsoon rains cause work to be abandoned in the rainy season. Hence, except in the few organized mines, workmen are drawn from the nearby villages when work is available.

An estimate carried out in 1906 gave the number employed in the plumbago mining industry as 16,700 males, 3,750 females and 15,000 dependants—total 36,000. The Ceylon census of 1921 gave the number of plumbago miners as 2,226. Half-yearly reports collected during recent years by the Inspector of Mines give the figures of the number of mines worked and labourers employed (excluding those employed in the industry outside the mines) as shown in Table 1.

TABLE 1

NUMBERS OF PLUMBAGO MINES AND EMPLOYEES IN CEYLON

Year	No. of mines worked in the year	No. of persons employed
1940	1,207	18,000
1941	858	16,500
1942	452	8,925
1943	199	8,452
1944	78	2,769
1945	60	2,153
1946	31	1,785

Nature of Labour in the Industry

Labour employed is totally indigenous and Sinhalese. The inhabitants of some villages have a special reputation as good miners, but the largest number of workers are obtained from the villages near the mines. It is common to find a familial tendency, a father teaching a son to follow the work he in turn had learnt from his own father. Women are employed in the curing work near the mines. They are often wives and relations of the miners.

Work in the mining industry is reputed to be hard and risky but is not considered unhealthy except for the fact that some of the mines are situated in the malarial districts of Ceylon.

Changes of temperature, from moist heat at the bottom to the cold air at the surface, and the physical stress of negotiating ladderways, are serious strains on any constitution; yet illness amongst plumbago miners is rare. The best of Ceylon's virile and athletic manhood and womanhood are seen in the plumbago-mining industry. Though there is no medical inspection on admission to the industry, there is a type of selection usually adopted by the mines. Inquiries are made of new entrants regarding the father's abilities, especially in mining, and also regarding any physical disabilities such as deafness, indistinct vision, deformities, etc., and only those who can satisfactorily carry out the duties of a miner are employed. This explains to a large extent the physical fitness of the miners.

Classes of Workers

There are four great classes of workers: (1) underground workers; (2) surface workers; (3) underground and surface workers; (4) workers in curing sheds.

Underground Workers.—These consist of various skilled workers. There are drillers, who drill holes in the rock near the plumbago veins. It is mostly hand drilling, but water is used to prevent dust formation. It is a skilled job, since by intelligently directing the drill holes much waste of rock can be avoided.

Blasters charge the holes with dynamite and fire them. Here too a good deal of intelligence is required to get the best results. Shaft drivers are responsible for driving shafts to various depths. Excavators separate the plumbago from pieces of blasted plumbago-bearing rock and plumbago veins. Muckers and trolleymen are engaged on the transport of plumbago pieces from the working level up to the pit head. Timbermen timber those shafts and tunnels which are not in rock, and also construct and repair ladderways.

Surface Workers.—These include blacksmiths, drill sharpeners, boilermen, carpenters, masons, carters, watchers, firewood splitters, and carriers.

Underground and Surface Workers.—These consist of mechanics, electricians, winchmen, hoisterners, pumpmen, and enginemen responsible for the mechanical and electrical machinery required in the mine.

Workers in Curing Sheds.—These, mostly women, are employed in sorting, chipping, crushing, screening, sifting, washing, polishing, and grinding the plumbago.

Depth at Work

Only five mines are worked below 300 feet, and out of these five only two are worked at 1,700 feet. These are the most important and well-organized mines in the island. Most of the other so called mines are worked within 100 feet of the surface.

Hours of Work

Several years ago there was a twenty-four-hour shift in the mining industry; a miner worked four shifts of five hours each; each shift was followed by an interval of one hour, and the following day he was free. This system does not exist in any of the plumbago mines today. The Wages Boards Ordinance, which was extended to the plumbago industry on September 1, 1945, defined the normal working day (inclusive of one hour for meals) as nine hours. A new Mining Ordinance, passed in 1947, limited the hours of work for underground miners to eight hours a day inclusive of an hour for meals, and to forty-eight hours during any six consecutive days; the time spent in the descent and ascent is included within this period. In practice, in some of the best-managed mines as Kahatagaha and Kolongaha, underground miners do not work more than five hours a day. They go down the mines at 7 a.m. and return to the surface before noon, after completing the task of work assigned to them. Usually two shifts are carried out in the underground mining work. Young persons and women are prohibited from doing underground work.

Occupational Hazards

Occupational hazards, if any, should be found mostly in the underground work and in the curing sheds. Samples from each group were subjected to clinical and *x*-ray examination, and the findings are given below. Fifty underground miners were obtained from Kahatagaha mines, Kolongaha mines in Dodangaslanda, and Bogala mines in Ruanwella. Those three mines were chosen as the oldest-worked (over seventy years) and deepest mines, and as being the only ones where there were miners who had worked regularly for more than fifteen years. Sixty-two plumbago curers were selected from five plumbago curing sheds in the outskirts of Colombo where work had been carried out for over thirty years. This group consisted of fifty-five females and seven males.

The occupational hazards in the industry were investigated under seven headings.

Accidents.—Accidents reported to the Inspector of Mines from all mines are shown in Table 2.

TABLE 2

ACCIDENTS IN CEYLON PLUMBAGO MINES

Year	Accidents	Deaths
1940	10	2
1941	19	16
1942	15	6
1943	8	3
1944	6	4
1945	—	—
1946	3	1

Absence of Sunlight.—The hæmoglobin percentages of the fifty miners examined did not show any anæmia. No diseases due to lack of sunlight were noticed amongst the miners. Nystagmus was looked for in 105 miners, but not a single case was detected. The three mines examined are well lit with electricity. When miners work in places not so lit, they usually carry with them a coconut oil lamp which gives them light.

Atmospheric Moisture and Temperature.—Both these depend to a great extent on the ventilation system of the plumbago mines. Readings were taken for a week at Kahatagaha mines by means of an automatic thermograph fixed at 400 feet below the pit-head. The temperature recorded was 78° F., with a variation of about a degree. The temperature in the electric lighted working galleries was one degree higher. Psychrometer readings were taken at the levels where automatic thermographs were fixed, and these showed relative humidities varying from 88 to 92 per cent.

Atmospheric Pollution.—Unlike the coal mines, plumbago mines are situated in solid granite rock and as such there are no fermentable carbonaceous matters to produce methane and other combustible gases within the mines. The only pollutions that can occur are from sulphuretted hydrogen, sulphur dioxide, and nitrous fumes emanating after blasting operations.

Working Posture.—Miner's beat elbow, miner's beat hand, and miner's beat knee cause a considerable amount of illness among coal-miners. These are due to the awkward and trying positions in which the coal-miners are obliged to work and which lead to undue pressure on certain portions of the body. Not a single case of these conditions was found among the fifty miners subjected to clinical investigation. Awkward working positions are lessened to a great extent, as the various galleries

and tunnels are nearly 6 feet in height, allowing miners to work and move about in normal posture. The skin, when covered with plumbago, has a protective slippery surface, which prevents the effects of undue pressure in one single place. Similarly eczematous dermatitis (miner's itch), commonly found in coal-miners due to the dust, to damp heat, and to friction, is not found among the plumbago miners. This is also probably due to the protective covering of plumbago on their skin which they get when at work, and to regular cleaning with soap and water.

Dangers of Infection and Infestation.—Well known infections, such as ankylostomiasis and spirochætosis, which are common in mines of other countries, are not common in Ceylon. The plumbago miner works barefoot, and though there is a fair amount of ankylostomiasis in the general population of Ceylon, the hæmoglobin percentages of those inspected did not show any anæmic condition. Sanitary facilities are provided to prevent ankylostomiasis infection; and plumbago mines, except for the water that is sprayed to prevent dust, are dry. Similarly no case of jaundice suggestive of any spirochætal infection is known to have occurred in the mines investigated.

Pneumoconiosis.—In plumbago mining a dust risk can occur in any of the following work processes: drilling of plumbago-bearing rocks, blasting, picking of plumbago, transport of plumbago from the bottom of the mines to the pit head, and curing of plumbago. To prevent dust formation, work places and plumbago collections during their transport within the mines are moistened with water. In this condition plumbago is not dust-forming. Plumbago dust is more adherent and heavier than coal dust and it is non-irritant. The consensus of opinion is that graphitosis due to continued inhalation of plumbago dust belongs to the harmless class of pneumoconiosis. To estimate the effects of continuous work in plumbago mines on the lungs, fifty persons who had worked continuously for over ten years in underground work were *x*-rayed. None of them had complained of any chest disease and at the time of examination no clinical signs or symptons were detected.

The age groups of the underground miners examined and the length of time they had worked as underground miners, are shown in Tables 3 and 4.

Of the radiographs of fifty underground plumbago miners, thirty-five showed no abnormalities, while fifteen showed abnormal shadows. These consisted of three cases of nodulation (see figs. 5 and 6), four of diffuse fibrosis of lung, one of fibrosis of bases, two of patchy opacity of uncertain ætiology, and five of calcified mediastinal glands.

The four persons who showed diffuse fibrosis of lungs had worked over twenty years as underground miners and were aged 45, 45, 50, and 38 respectively.

TABLE 3

AGE GROUPS OF UNDERGROUND MINERS EXAMINED

Age-group	No. of miners
25–30 years	6
31–35 ,,	8
36–40 ,,	17
41–45 ,,	14
46–50 ,,	5
Total ..	50

TABLE 4

YEARS OF WORKING UNDERGROUND OF MINERS EXAMINED

No. of years	No. of persons
10–15	10
15–20	19
20–25	16
25–30	5
Total ..	50

Plumbago Curers.—Sixty-two persons employed at the plumbago curing sheds near Colombo were clinically and radiologically examined (Table 5) and the findings are given in Table 6.

TABLE 5.

AGE GROUPS OF THE PLUMBAGO CURERS EXAMINED

Age-group	Males	Females
10–30 years	3	16
31–35 ,,	—	6
36–40 ,,	—	9
41–45 ,,	2	5
46–50 ,,	1	7
50 years and over	1	12
Total ..	7	55

Physical signs of the lungs were normal in thirty-three persons. Radiologically, fifty-one showed abnormalities varying from fine striation to gross disease. Mantoux tests were carried out in this group, and 83 per cent. of positive results were obtained. The Mantoux incidence for the normal population of this area, according to the figures obtained from the medical officer in charge of the Tuberculosis Survey, is 55 per cent. Hence this group has a Mantoux incidence 28 per cent. higher than that of the normal population of the area.

TABLE 6
DURATION OF WORK AND ABNORMALITIES

Duration of work	Fine striation	Gross striation	Nodulation and mettling	Disease
Under 5 years	9 (2)	1 (1)	1 (x)	—
5–10 ,,	8 (2)	—	3 (p)	—
10–15 ,,	5	—	1	—
15–20 ,,	5 (2)	—	1	1
20–25 ,,	2	1	1	—
Over 25 ,,	2	3	1	—
Total ..	34	6	10	1

(x) = No. with eosinophilia over 20 per cent.
(p) = pleural effusion.

In my opinion, the dust hazard amongst plumbago curers in the sheds near Colombo is greater than in those working in the mines, as the finer curing processes cannot be moistened with water to prevent dust. Almost all the work is done by manual labour without the use of any protective measures.

Summary

1. The plumbago mining industry in Ceylon is only about 125 years old. Employment in the industry is intermittent; except in a few mines there is no regular employment.

2. In contradistinction to coal, marketable plumbago is found in deposits between solid granite rock. It is therefore necessary to blast shafts and tunnels through the rock.

3. Because of a method of selection carried out by the mine owners on admission of miners to the industry, the best of Ceylon's manhood is found in the mining industry.

4. With the exception of six well-managed mines, all are worked within 100 feet of the surface. The three best-managed mines are worked from 500 to 1,500 feet below the pit-head.

5. In three mines modern machinery and electricity are used to minimize the burden of the miners. The safety measures and ventilation systems provided are up to modern requirements.

6. Conditions such as miner's elbow, miner's hand, miner's knee, miner's itch, and nystagmus are not common amongst plumbago miners.

7. To prevent a dust hazard, what is called the "wet system" is used in various work processes. Lung disease is very rare among underground miners. Fifty persons who had worked for over ten years as underground miners were examined radiologically and, though they had no clinical symptoms of chest disease, radiographs in four persons showed diffuse fibrosis of the lungs.

8. The general health of persons employed in the plumbago mining industry is satisfactory. Skin diseases are practically non-existent. The hæmoglobin percentage, urine, and blood pressure in fifty persons examined were normal.

9. Sixty-two persons employed in the plumbago curing sheds near Colombo where there is a greater dust hazard were examined clinically and radiologically. Clinically only thirty-three persons (53 per cent.) showed normal lungs. Radiologically fifty-one persons (82 per cent.) showed abnormalities varying from fine striation to gross disease. Lung abnormalities seem to increase with increasing of length of service in plumbago curing. Mantoux tests carried out showed an incidence of 83 per cent. of positive results.

10. The general health of the workers in the plumbago curing sheds is far from satisfactory. They incur a very considerable dust hazard in comparison to the underground miners in the plumbago mining industry. No protective measures are used by the plumbago curers to safeguard them from the dust hazard.

My thanks are due to Col. C. J. D. Lanktree, C.C.S., Commissioner of Labour, Ceylon, for allowing me to publish this paper on material obtained in the course of an official investigation which I carried out for the Labour Department of Ceylon.

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DIATOMACEOUS EARTH SILICOSIS

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Diatomaceous earth and tripoli are hydrated amorphous silica minerals of organic origin, which are generally considered to be a variety of opal. The diatomaceous earth or diatomite (German : Kieselgur ; Italian : farina fossile), are found in the lake deposits of innumerable diatom shells : it forms a very porous mass, sometimes loose and floury, sometimes compact and claylike, always very light—white, grey, or yellowish. Tripoli on the other hand is a marine sediment mainly composed of skeletons of radiolarii : it is more compact and generally light, often containing well-preserved fossils of fish and shellfish.

After quarrying, drying, and pulverizing, diatomaceous earth is marketed for a great variety of industrial purposes, including dynamite, refractory bricks, and filters for drinking water or wine or syrups ; it is also used as an insulating material. Tripoli is less used but is especially valuable for polishing metals, precious stones, and the like.

Diatomite is chiefly formed of amorphous hydrated silica (SiO_2nH_2O) and in small part (2 to 6 per cent.) of basic oxides.

Silicosis-Producing Power of Diatomaceous Earth

The great surface of the diatomaceous earth particles, and the greater water solubility of the hydrated amorphous silica of which they are formed, in comparison with quartz, are considered important silicosis-producing factors by those who hold the disease to be caused by the solution of silicon dioxide in organic fluids. Beger (1934) thinks that the speed and severity of the silicosis seen in abrasive soap factories depend on the solubility of the diatomaceous earth which is sometimes used for abrasive purposes.

Experimentally diatomite has shown a high silicosis-producing power. Podwyssozki (1910) produced true granulomatous growths by introducing diatomite dust subcutaneously into animals. By diatomite inhalation in rabbits Beintker (1935) and Siegmund (1934) obtained a formation of nodules very like those seen in human silicosis. In order to determine whether or not tripoli is capable of producing silicosis, McCord (1936) introduced 0·1 g. of tripoli in 2 c.cm. of physiologic saline into the peritoneal cavities of male guinea-pigs. At the end of thirty days all tripoli-injected animals were killed : in every instance extensive and characteristic proliferation was established. The nodules produced were typical of those for quartz silica and in all respects permitted the interpretation that the action of tripoli is the stimulation of a proliferative response.

Proliferative responses, cellular in type, were set up by Solowiev and Pinus (1928), by Policard (1936, 1940), (whose albino rats, after inhaling pure diatomite dust, showed an extraordinary monocytic reaction in the lung alveoli, without any evidence of fibrosis and widely differing from the type of reaction set up by quartz), and quite recently by Duvoir, Derobert, and Journet (1946).

In human pathology a case of diatomite silicosis was recorded in 1932 by Adler-Herzmark and Selinger (1932) in a worker who had been employed for eight years grinding and packing diatomite : the fibrosis, not exceeding in extent the palm of a hand, was slightly reticular in type and was limited to the lower parts of the lung near the hila. In the same year Legge and Rosencrantz (1932) published an investigation, unfortunately almost forgotten in the silicosis literature, on 118 workers of a diatomite quarry in the region of Santa Barbara, California, exposed to the inhalation of large quantities of dust. Eighty-one cases with radiographic abnormalities were discovered, including sixty with early stages of silicosis, fifteen with fairly advanced, and six with advanced stages. Eighty-six workers had clubbed fingers, but only eight showed generally impaired conditions : light and moderately advanced

silicosis were to be seen after one to two years' work ; in one case the silicosis was severe after less than five years' work.

Notwithstanding the observations of Legge and Rosencrantz and the ready demonstration of experimental silicosis from diatomaceous earth and from tripoli, these two substances are commonly held to be of little or no importance in producing silicosis in man. McCord (1936) points out, that in compensation cases in which silicosis has been falsely attributed to tripoli, qualified industrial hygienists have denied that tripoli may be a source of that disease. The chief basis for this attitude lies in the absence of evidence of characteristic silicosis in the skiagrams of workers long employed in industries utilizing diatomite or tripoli. Gardner's (1940) statement that amorphous silica is less silicosis-producing than crystalline silica contributed largely to the widespread opinion that diatomite dust is not very dangerous to human beings.

As a matter of fact, Gudjonsson (1934) failed to find silicosis in workers who for many years had quarried and pulverized diatomite, in spite of high dust production. In three workers who worked with diatomaceous earth Nuck (1934) failed to find radiographic evidence of silicosis ; also Beintker's researches on numerous workers extracting and working up diatomite in the German districts of Lüneburg and Hannover were negative. Later Nordmann (1943) reported that in the same district of Lüneburg Nuck discovered a silicosis-like pneumoconiosis among Kieselgur workers ; Nordmann himself published a set of six autopsy findings, which will be mentioned later : in these cases, however, the action of a considerable amount of quartz cannot be excluded. Middleton (1936) on *x*-ray examination of many workers who had been exposed for ten years to diatomite dust, found only two cases of slight fibrosis.

Quite recently Martin and others (1947) examined thirty-two workers exposed for many years to heavy concentrations of diatomite dust : only three showed an *x*-ray appearance of mild, initial pneumoconiosis of the asbestosis type, and of these only one had functional impairment : they concluded that, although a diatomite dust pneumoconiosis undoubtedly exists, it is much milder both radiographically and clinically than would have been expected from the high content of free silica in the diatomite.

Some radiographs of cases of pneumoconiosis produced by Fuller's earth (a mineral substance of indefinite composition, containing amorphous silica (SiO_2nH_2O) and thus somewhat resembling diatomite) were presented by Middleton at the Silicosis Conference in Geneva in 1938. One patient, with thirty-five years' exposure to Fuller's earth dust, showed fine punctate nodulation with some aggregation of shadows ; a second, with thirty-nine years' exposure, showed shadows suggesting nodulation with a linear arrangement ; yet Policard (1940) inclined to explain the radiographic findings by the presence in the Fuller's earth of heavy metallic compounds arresting the *x* rays and producing shadows interpreted as fibrosis. Two other cases of pneumoconiosis from Fuller's earth are reported by Campbell (1940) : one patient died at the age of 56 after having worked continuously on the mill from 1908 to 1919. He had suffered from cough and dyspnœa during the last few years and was incapacitated eighteen months before his death. An autopsy was made by Dr. S. R. Gloyne. In the lower parts of the lungs there was extensive visible and palpable dust fibrosis, in the main of a cellular-reticular type and without the dense acellular whirls and nodules commonly found in fully developed silicosis. There were also dark masses in the upper parts of the lungs, but these were not examined microscopically.

Technical Data

We have been able to observe several cases of advanced silicosis caused by inhalation of diatomite dust among workers employed in the manufacture of filter candles. The two factories considered in the present work will be called respectively IG and ZA.

A brief description of the materials used and of the working procedure is given below.

Diatomite comes ready ground from the quarries of Monte Amiata, Tuscany. Its chemical composition is : silica (SiO_2) 82% ; water 12·4% ; Alumina and iron oxide 4·2% ; chalk 0·55% ; magnesia 0·45%.

Filter candles are manufactured as follows. Diatomaceous earth is mixed with small quantities of charcoal and pure calcined magnesite, according to the required properties of the candles, generally in the following proportion : 25 kg. diatomite, 5 kg. charcoal, and 2 kg. magnesite. The mixture is thoroughly ground and parallelepipeds measuring $35 \times 10 \times 10$ cm. are formed with the addition of water. They are dried in the open air and then turned to cylinders by hand, and calcined at 1250° C. After ignition, during which charcoal is burned out, the cylinders have a white or slight yellowish appearance, and are light, talc-like, very finely spongy, and easily broken. This first working process is carried out in IG factory only ; ZA factory receives the cylinders already calcined from the IG plant. In the second stage of the process, which is carried on in both factories in a department called " turning of the candles," the cylinders or candles are machine-turned until they reach the required diameter, which is different for the various types of candle (from 2 to 6 cm.). The candles are then perforated along their whole length with a boring

machine; the diameter of the hole is about equal to half the diameter of the candle, and it terminates from ½ to 3 cm. from one end. The candles are then fitted on a metallic support, and thereafter are mechanically limed and polished with emery paper, tested, sorted, dusted, and smoothed by hand, and finally sent to another department, where silvering is performed. Each candle is dropped into an aqueous solution of silver nitrate which penetrates into it and is then reduced to metallic silver by special treatment.

Turning, boring, liming, and finishing are always performed by dry methods and thus raise much dust: the very fine and light dust has a great tendency to float in the air and to pervade the whole department. Therefore not only the turners and finishers, but also the testers, the sorters, and the fitters—whose work is not in itself dust-producing—are exposed to the inhalation of dust.

The Present Investigation

Workers in these two factories making filter-candles (basically similar to Chamberland and Berkefeld candles), who had worked in the turning department from more than one year, were *x*-rayed and examined in 1944, and from then on once a year. The more serious cases were admitted to the Clinic for Occupational Diseases of the University of Milan.

The turning department of IG plant is small, badly ventilated, extremely dusty, and lacking in fans. In 1944 there were in it five workers who had been employed for more than one year. Of these, two had normal radiographs, two had advanced silicosis, and one had advanced silicosis with open tuberculosis.

The turning department of ZA factory is large and modern and has many windows. Since 1944, when the first cases of silicosis were detected, the lathes and drills have been equipped with powerful exhaust, so that dustiness has been largely reduced. In 1945 dust counts carried out with the thermal precipitator gave the following results: near the grinding wheel without exhaust 500 p.p. c.cm.; near the lathe 450 p.p. c.cm.; in the middle of the department 400 p.p. c.cm. (dust counts performed with magnification of 200). The size of the dust particles ranged between 0·5 and 2 μ.

In 1944 in this department there were fifteen workers who had been employed for over one year. Five were normal, and ten showed silicotic lung changes, two reticular fibrosis, four reticular fibrosis with nodulation-like appearance, and four conglomerate silicosis.

In all, out of twenty workers radiographed in the two factories, thirteen were silicotic, of whom seven were in an advanced stage and one had open tuberculosis. From 1944 up to date, two workers have died, one of silico-tuberculosis and the other of silicosis: several became incapacitated and were obliged to leave work; six were pensioned by the National Accident Insurance Institute.

Case Reports

Case 1.—A man aged 35, who worked for ten years as a candle turner in IG factory, has suffered for two years from shortness of breath on going upstairs and bicycling. He still continues to work, though he has dullness in the upper fields of the lungs, with high-pitched breath sounds, an erythrocyte sedimentation rate (Westergren) of 2 mm. in the first hour, and a Katz index of 2·5. Vital capacity is 2,500 c.cm., and breath-holding time 25 secs. The sputum contains no tubercle bacilli. The radiograph shows reticular-nodular fibrosis with large coalescence in the upper fields, especially in the infraclavicular zone and in the right middle field; the left lung root is raised; the lower zones of the lung fields show emphysema (fig. 1). The diagnosis is of nodular-interstitial coalescent silicosis.

Case 2.—A man aged 36, a raw candle turner for five years (not a dust-producing procedure), and a calcined candle turner for five years, in IG plant, has for one year suffered from dyspnœa on slight exertion, dry cough, pains in the chest, occasionally slight fever, and sometimes night sweats and loss of weight and appetite. He is of wasted physique (height 165 cm., weight 46 kg.). There is a dull percussion note over the upper lung zones, with sharp, almost tubular breathing. The blood sedimentation rate is 2 mm. in the first hour, the Katz index 2. The sputum contains no tubercle bacilli. The vital capacity is 3,000 c.cm., the breath-holding time 27 secs. The temperature is normal. The radiograph shows very intense reticular-micronodular fibrosis, especially in both subclavicular zones, where a tendency to conglomeration is seen. The left lung root is displaced toward the apex; both lower lung zones are emphysematous (fig. 2). The diagnosis is of micronodular silicosis with conglomeration in the upper fields.

Case 3.—A man aged 31, a candle turner in IG plant for seven years, up to 1942 went in for many sports, such as skiing, swimming, and climbing. In March, 1944, the temperature rose to 38° C., and he developed productive cough, marked dyspnœa on exertion, loss of weight, tiredness, and loss of appetite. Clinical findings in June, 1944, showed him to be of wasted physique with a pale, toxic appearance. There was dullness of the whole of the left lung, with bronchial breathing and numerous crackling rales in the scapulo-vertebral zone. The radiograph showed intense irregular fibrosis of the right lung, with reticulation, nodules and fluffy patches in the upper zones. The left lung showed nearly total opacity, except for the apex and the bases: in the middle field there was a large cavity. Death occurred in October, 1944; an autopsy could not be performed. The diagnosis was of coalescent silicosis with tuberculous cavitation of the left lung.

Case 4.—A man aged 42, a raw candle turner for two years, and then a calcined candle turner and approver for nine years in factory ZA, since 1944 has suffered from dyspnœa on exertion, cough with scanty sputum, and

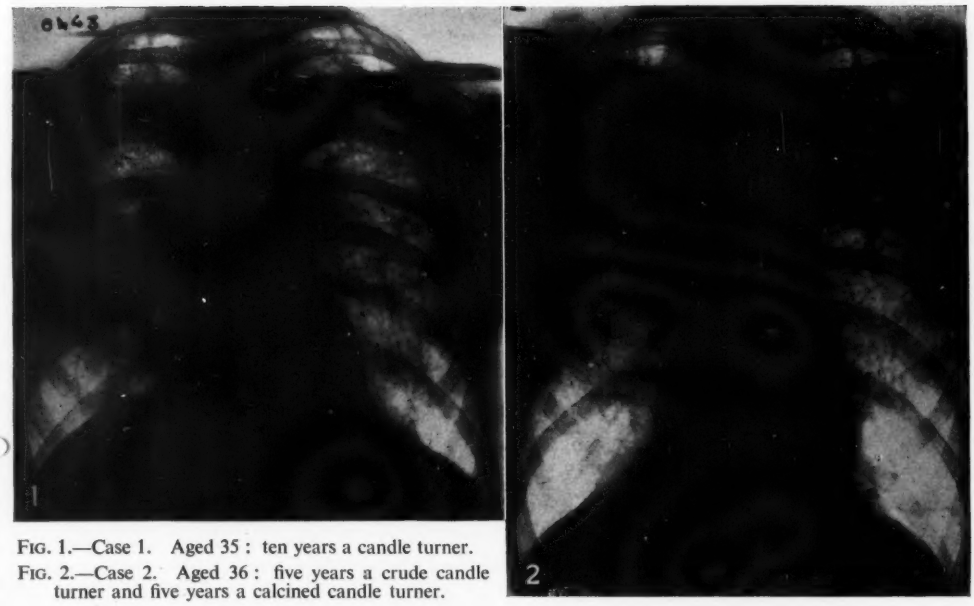


FIG. 1.—Case 1. Aged 35 : ten years a candle turner.
FIG. 2.—Case 2. Aged 36 : five years a crude candle turner and five years a calcined candle turner.

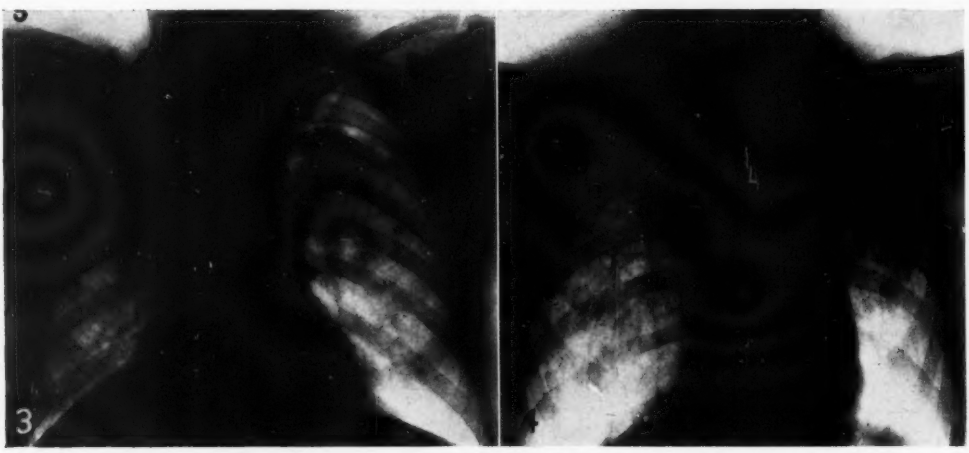


FIG. 3.—Case 4. Aged 42 : nine years a calcined candle turner and approver.
FIG. 4.—Case 5. Aged 60 : twelve years a candle driller.

FIG. 5.—Case 6. A woman aged 45 : four and a half years a candle fitter.

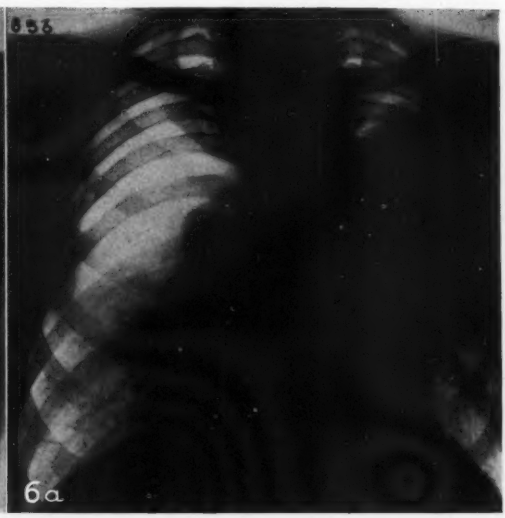


FIG. 6a—Case 7 Aged 41 : eleven years a candle turner. Radiograph taken April, 1945.

FIG. 6b—Case 7. Radiograph taken two months later than 6a.

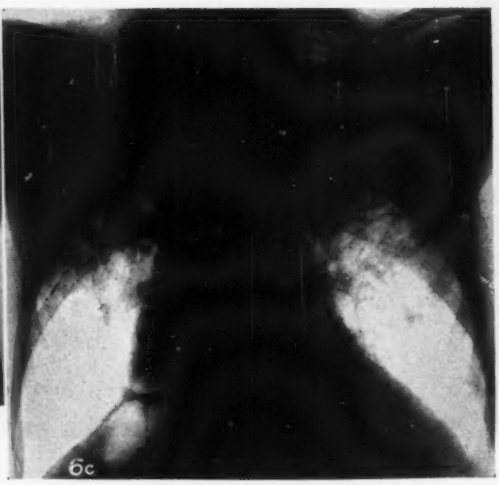


FIG. 6c—Case 7. Radiograph taken November, 1946

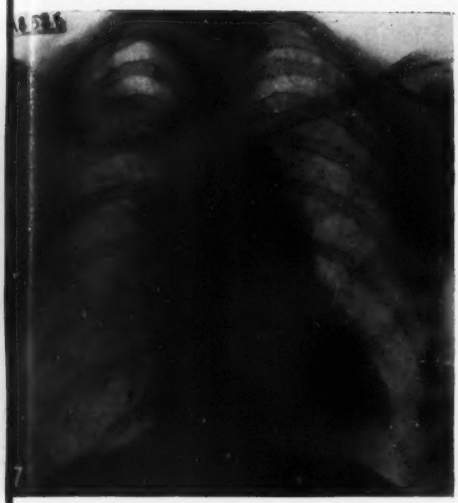
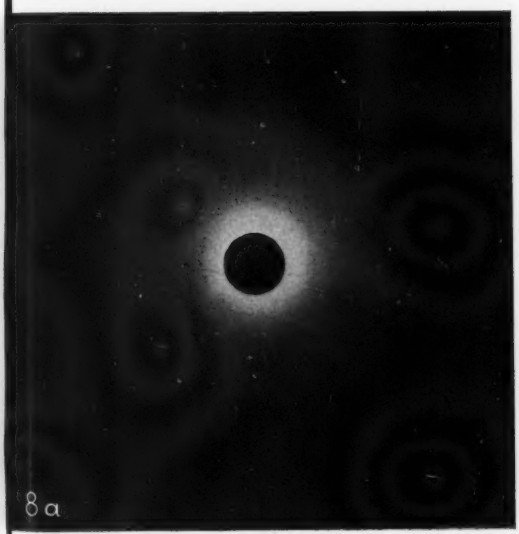
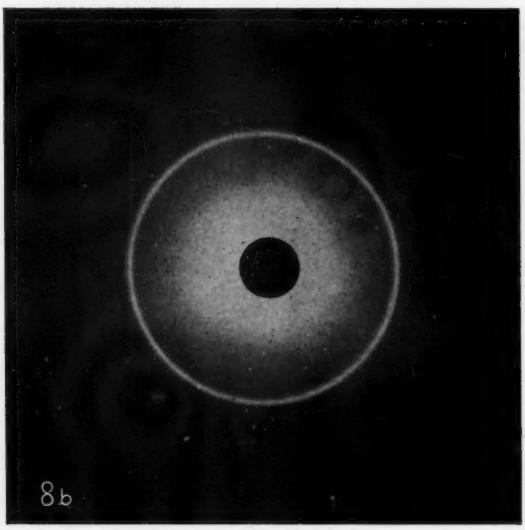


FIG. 7.—Case 11. A woman aged 50: seven years a candle fitter.

FIG. 8a.—*X*-ray diffraction pattern of crude diatomaceous earth, showing the absence of crystalline structure.

FIG. 8b.—*X*-ray diffraction pattern of diatomaceous earth calcined at 1,250° C., showing the spectrum of cristobalite.





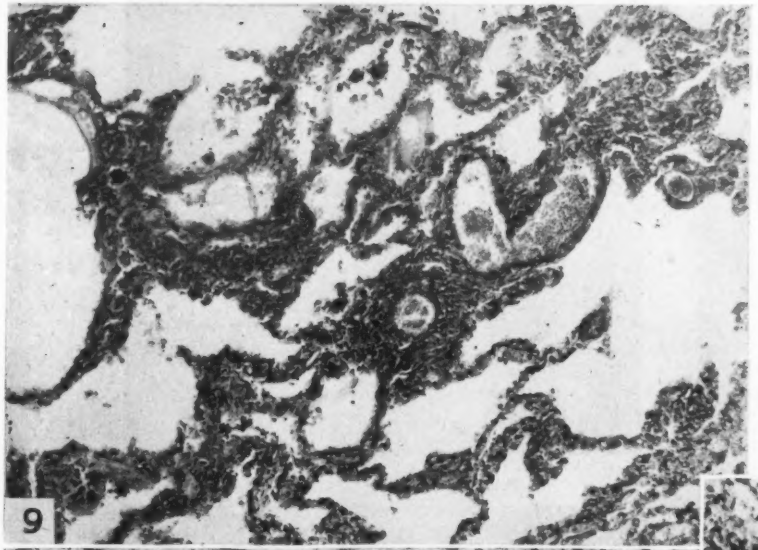


FIG. 9.—Lung: alveolar walls thickened by cellular hyperplasia. ×100

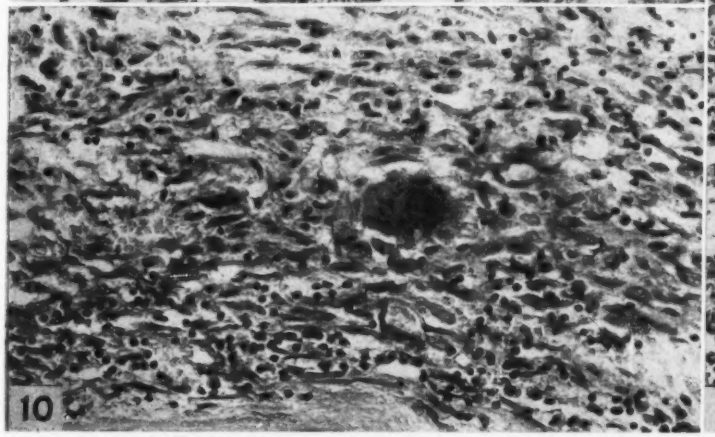


FIG. 10.—Lung: fibrotic area; granulomatous appearance with a giant cell. ×300.

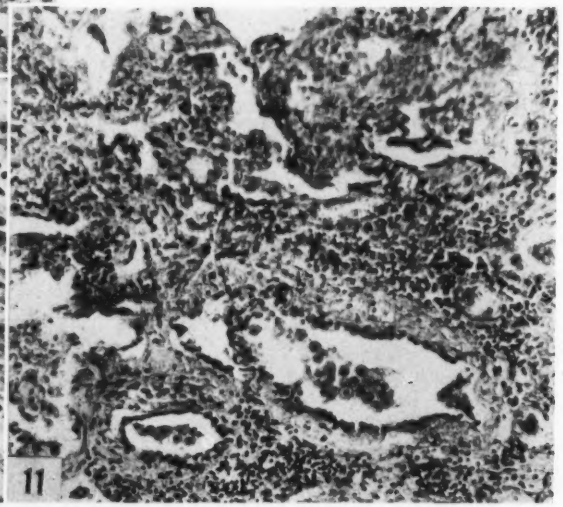


FIG. 11.—Lung: semi-consolidated area; bronchioli and air spaces with epithelial lining. ×150.

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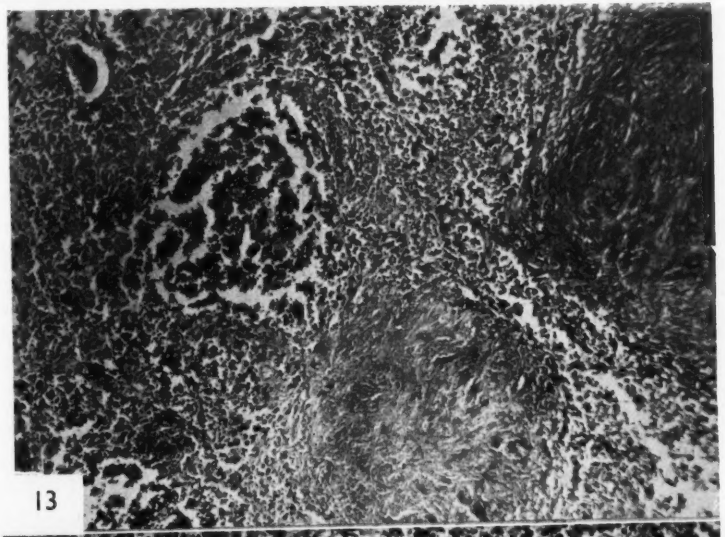

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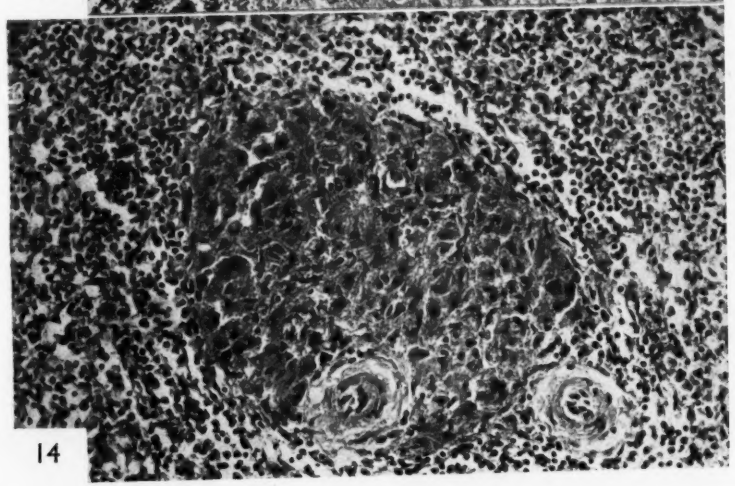

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FIG. 12.—Lung : thickened alveolar septa ; emphysematous and consolidated areas. ×15.

FIG. 13.—Lymph node : Lympho-reticular tissue islets surrounded with hyperplastic macrophages ; hyaline sclerosis. ×100.

FIG. 14.—Spleen : heap of epitheloid cells connected with arteriolar branches of a Malpighian body. ×200.

acute feverish bronchitis in the winter. In January, 1947, he suddenly had severe dyspnœa with cough and slight fever; he stayed at home for a month, then took up work again in spite of shortness of breath. In March, 1947, the clinical status was fairly good, though there was dyspnœa during the examination and slight cyanosis of the lips. The right lung had a flat percussion note in the upper zone, with very sharp breath sounds. The left lung had an impaired percussion note in the scapulo-vertebral zone, with very poor air entry. The radiograph revealed large fluffy shadows in the whole upper region and intense reticulation in the lower right field. There was pneumothorax at the left apex. The left lung showed fibrosis, especially in the upper zone. The upper mediastinum was poorly defined and displaced to the right (fig. 3). The diagnosis is of conglomerate silicosis with left pneumothorax.

Case 5.—A man aged 60, a calcined candle driller for twelve years in factory ZA, since 1943 has had progressive dyspnœa, and since 1944 persistent, unproductive cough. In 1943 he was sent to a sanatorium, from which he was dismissed after eleven months, with a diagnosis of silicosis. When examined in March, 1947, it was observed that his physique had become much worse since 1944. There was great wasting (weight 43 kg.), severe dyspnœa on minimal exertion, and persistent cough with scanty tenacious sputum, but no tubercle bacilli could be found in the sputum. There were clinical signs of coalescent fibrosis of the upper parts of the lungs, with dry, charkling rales. The erythrocyte sedimentation rate was 2 mm. in the first hour, and the Katz index 2. The tuberculin test was negative, and the temperature normal. The vital capacity was 1,000 c.cm., the breath-holding time 10 secs. The electrocardiogram was normal.

The radiograph showed marked pulmonary and pleural fibrosis of the upper left lobe, with rib contraction and displacement of the upper mediastinum towards the left; a golf-ball-like fibrotic conglomerate in the infraclavicular left zone; and marked emphysema in the lower half of the left lung, with many rainroads. There was coarse reticular fibrosis with coalescent nodules in the upper region of the right lung; and in the lower region more emphysema than fibrosis, with many rainroads. The heart was elongated and thin, displaced towards the left. There were pleural-diaphragmatic adhesions (fig. 4).

The diagnosis is of interstitial-nodular conglomerated silicosis, with fibro-thorax on the left side and marked emphysema.

Case 6.—A woman, aged 45, from October, 1940, to May, 1945, was a fitter in the candle-turning department: she worked near the lathe. From 1944 she experienced a feeling of weight in the shoulders, and in the winter suffered from bronchitis; there was loss of weight. After 1945 conditions became worse: she works now and then sweeping the factory offices. There is light dyspnœa at rest, persistent cough, and stabbing pains in the heart region. Examination in November, 1946, showed a wasted physique and slight cyanosis of the lips (height 153 cm., weight 39 kg., 30 breaths per minute, pulse 100). The chest was very thin, and there was flatness of percussion note on both lungs except at the right apex and left base, where hyper-resonance was noted. Breath sounds were very sharp, with dry rales and rhonchi; at the right apex breath sounds were feeble. Hæmoglobin was 70, red cells 3,320,000 per c.mm., sedimentation rate 30 mm. in the first hour, and the Katz index 30. There were no tubercle bacilli in the sputum, and the temperature was normal.

The radiograph showed marked reticular and micronodular fibrosis, more severe at both infraclavicular zones and at the right base, where a tendency to conglomeration could be seen. The heart configuration was ill defined, the right lung root enlarged and thickened. Pneumothorax was present in the upper portion of the right pleural cavity (fig. 5). The diagnosis was of reticulo-nodular silicosis with right pneumothorax.

Case 7.—A man aged 41, a candle turner for eleven years, in factory ZA, since 1944 suffered from dyspnœa on exertion and cough. He lost 10 kg. in weight. There was some fever up to 38° C. (100·4° F.). In April, 1945, he had a sudden feeling of suffocation with spontaneous bilateral pneumothorax (fig. 6a). He recovered from the pneumothorax in two months (fig. 6b). After this he remained at home, almost always in bed, and often had bronchitis with fever, severe dyspnœa, and productive cough. By November, 1946, he had dyspnœa also at rest, very persistent cough, dyspepsia, and a feeling of exhaustion. He looked pale, wasted, and suffering (his height was 163 cm., his weight 42 kg., his respiration rate 24, and pulse 106 per minute). He breathed with difficulty and had very poor chest expansion. There were clinical signs of intense fibrosis of the upper half of the lungs with emphysema of the lower parts; also widespread musical rhonchi with prolonged expiration. The second heart sound at the pulmonary area was accentuated and reduplicated.

The radiograph showed very extensive fibrosis, reticular and patchy, shadowing almost homogeneously both upper halves of the lungs except the left apex. The lung roots were displaced toward the upper parts of the mediastinum. There was marked emphysema in the lower zones of the lungs (fig. 6c). On Jan. 10, 1947, there was suddenly extremely severe dyspnœa, faintness, and stabbing pains in the ribs, but no fever. Death occurred in two hours. The diagnosis was of conglomerate silicosis, with emphysema. (The autopsy is reported in the section on pathology.)

Other cases of silicosis are the following: *case* 8, a woman aged 44, a candle fitter for six years, who has moderately diffused reticular fibrosis: *case* 9, a woman aged 40, a candle finisher for five and a half years, who has marked diffuse reticular fibrosis with early nodulation in the lower parts of the lungs; *case* 10, a woman aged 48, a candle fitter for four years, who has reticular fibrosis with early nodulation; *case* 11, a woman aged 50, formerly fourteen years a cup turner in a pottery works (wet process), and now a candle fitter for seven years, who frequently has bronchitis in the winter, with productive cough, dyspnœa on exertion, and loss of weight (the radiograph shows very marked reticular fibrosis with scattered little fibrotic patches (fig. 7)).

Case 12, a man aged 56, twelve years a candle washer, then twelve years manager of the candle-turning department, who has high blood pressure (200/115 mm. Hg.) and marked reticular fibrosis with micronodulation in the lower lung regions; *case* 14, a woman aged 40, ten years a candle finisher, who has moderately advanced reticulation, especially in the lower fields; and *case* 15, a man aged 56, who spent three years in a candle-turning department and has reticulation in the lower fields*.

Pathology

Autopsy was performed on one of the patients (Case 7), who had been working eleven years exposed to calcined diatomaceous earth dust. The autopsy (Prof. Cattabeni), not mentioning lung findings on which we shall later make a fuller report, showed a conspicuous degree of consumption, the right heart dilated and hypertrophied, and multiple fibrous pleural adhesions with hæmorrhagic effusions under the pleuræ. Spleen, liver, and kidneys had signs of subchronic stasis. In the stomach was a scar from pyloric ulcer and congestive gastritis from stasis.

For our studies we had at our disposal both the lungs, many root and mediastinal lymph nodes, and part of the spleen. The pieces were fixed in 10 per cent. formol.

Lung: Gross Findings.—The lungs were both very much solidified, with fibrotic firmness in the cranial and middle parts. The condensed parts were not so hard and compact as in ordinary massive silicosis; they were blackish-grey in colour, with lighter grey stripes. They did not show any nodulation. Close to the condensed tissue in the middle parts could be seen many big emphysematous bubbles, generally subpleural; some up to 2 cm. in size, empty, with smooth walls. The lower middle zones had grown in firmness in a diffused and moderate way. Parts of the base were very emphysematous; touching them one could feel occasional irregular solidification. Root and mediastinal lymph nodes were not much enlarged; they were greyish-black, of hard, elastic firmness, juicy, and did not "shriek" when cut. Fragments of fibrotic tissue inoculated into four guinea-pigs failed to produce any evidence of tuberculosis after forty-five days.

Histological Lung Findings (figs. 9—12).—The whole lung parenchyma shows very intense congestion, especially in the capillaries. The air spaces were filled partly with iron pigments and very fine blackish-grey grains that did not react as iron. Most of the walls of the alveoli were quite thick owing to the great quantity of mononuclear cells with large cytoplasm, including very fine granules which could be demonstrated only with difficulty. These cells were irregularly accumulated; no distinct epithelial lining could be seen on the inner surface of the air spaces. Argyrophilic fibrils were present among these cells, but the collagenic ones were scarce; the elastic fibres were sometimes increased, sometimes decreased, the blood capillaries were filled with blood and appeared tortuous. The thickening of the air spaces where these met the consolidated segments was so conspicuous that the lumina were extremely reduced and sometimes they even disappeared; there were large compact fields in which all air-space architecture has disappeared and had been replaced by continuous and homogeneous amounts of cells similar to the ones we had noticed in the septa. Among these cells an occasional giant cell was seen, with small nuclei arranged centrally or sometimes peripherally. There were no tubercle-like cell aggregations, and no caseation. In these compact fields the sclerotic character was manifest: there were no elastic fibres; the numerous argyrophilic fibrils yielded to collagenic ones and to hyaline masses. A few remaining air-spaces included in the sclerotic fields were lined with cubic epithelium with gland-like appearances. In the most compact areas very few cells were scattered among the strands of fibrotic and hyalinized connective tissue.

The areas less affected by the cellular infiltration and by the sclerosis showed evidence of emphysematous dilatation of alveolar ducts and of the alveoli.

The unstriped muscular cells both of the bronchi and small arteries were increased in quantity. The bronchial lumina contained a great quantity of desquamated columnar cells, mixed with mucus and accumulated in compact heaps, which obstructed the lumina of the minor bronchi.

Histological Findings on the Regional Lymph Nodes of the Lungs (fig. 13).—In the lymph sinuses there were great numbers of cells containing hæmosiderin. Outside the sinuses infrequent islets of unaltered lympho-reticular tissue were to be seen, but most of the tissue was formed by epithelioid cells distributed in a homogeneous way, round, polygonal, or short spindle-shaped, containing in their cytoplasm many greyish-black powdery granules. The reticulum, stainable with silver, was here plentiful. Also the blood capillary network was quite evident among these cells, and their walls were thickened and intimately associated with the reticulum itself. Reticulum and capillaries became, through gradual thickening and collagenification, a fibrous network whose cells were more sparse and ended by constituting coarse and hyalinized collagenous masses, sometimes with concentric lamellar arrangements of silicotic type. Small foci of calcification were sometimes seen. Among the epithelioid cells very rare giant cells, as described in the lung, were scattered without any tubercular aggregation or caseation.

Spleen: Histological Findings (fig. 14).—Sub-chronic venous congestion was marked. Around the periphery

* Another severe case came recently from a third factory manufacturing filtering candles. A man, aged 43, ten years a turner of calcined candles (1930—1940), since 1940 has suffered from cough, exertion dyspnœa, and progressive wasting. In October, 1940, he had empyema; since that year he has been repeatedly in tuberculosis sanatoria, but he has been without fever and without tubercle bacilli in the sputum. In July, 1947, his physique was wasted, his height 168 cm., and his weight 48 kg. There was dullness in the upper fields of the lungs, with very sharp breathing. The erythrocyte sedimentation rate (Westergren) was 4 mm. in the first hour, seven in the second; Katz index, 4. The Hb was 54, red cells 3,610,000 per c.mm., white cells 4,100. The vital capacity was 1,600 c.cm., and the breath-holding time 16 secs. The radiograph showed interstitial nodular fibrosis, with coalescence in the left subclavicular zone and intense emphysema at the left lower lobe. There were calcified lymph nodes at the right root, and costotomy at the tenth rib, with pleural adherences at the right base. The diagnosis is of interstitial nodular silicosis, with coalescence and marked emphysema, the sequelæ of right emphema.

or in the framework of some Malpighian bodies, closely connected with arteriolar branches, could be seen little heaps of epithelioid cells which were quite similar to those in the lymph nodes; the transparency of their cytoplasm was almost obscured by very fine and hardly visible grey granules. Signs of sclerotic evolution were almost completely lacking. There were no giant cells.

Dust Storage in the Tissues.—By incinerating (in an electric oven at 500° C.) tissue sections, stained or unstained, applied on the glass slide according to the Rüttner and De Quervain (1947) method, we obtained spodograms very rich in ash. Some points, chosen on the sections and marked by means of the nonius microscope, were afterwards looked for on the spodogram, before and after treatment in hot nitrohydrochloric acid. On microscopic examination most of the ash was seen to disappear after treatment in nitrohydrochloric acid; the remaining particles were formed of very fine grains, partly visible but only by means of lateral lighting; the grains did not show a clearly crystalline structure, nor any form referable to diatomaceous fragments. Only very seldom did we find in the lung spodograms—and only once in a section of lymph node—small cylindrical refracting sticks with ends as if cut off, nearly 1 μ thick and 3 to 8 μ long. Examination by means of the polarizing microscope showed some very infrequent bi-refringent small crystals; most of the grains were not of this kind.

This dust could not be clearly recognized as diatomaceous. It should be noted that calcined diatomaceous earth dust shows rare and slight traces of centric, feather-and-comb-like structures which are characteristic of the crude dust, but that it is made up of very small structureless grains.

Dust grains resisting nitrohydrochloric-acid treatment corresponded to the following principal histological spots: (*a*) *in the lungs* we saw a great quantity of dust on the thickened walls of the air spaces, in the consolidated masses, and in the free alveolar cells; (*b*) *in the lymph nodes* small particles of dust were everywhere, being very sparse in the lymphocytic tissue, but abundant in the epithelioid cells and in the sclerotic masses; (*c*) *in the spleen*, dust was usually sparse and made up of quite small particles, mainly stored in the nodes of epithelioid cells; the rest in the red pulp. The lymphocytic Malpighian bodies and the connective tissue of the trabeculæ and of the vessels were free.

Comment on the Pathological Findings

The lung changes occurred after eleven years' exposure to the calcined diatomaceous earth dust and in the final stage become a diffuse fibrotic and hyaline sclerosis fairly similar to that of the massive quartz silicosis. But we have noted some important differences from the usual quartz silicosis: lack of hyalinized single or conglomerated nodules, and different feature of the changes leading to sclerosis. These changes consist in a diffuse cellular thickening of the walls of the lung air spaces, produced by proliferation of dust phagocytes. This proliferation becomes gradually so marked that it replaces every air space and initiates a massive granuloma which only in a very late stage becomes fibrotic. Emphysema, dilatation of blood capillaries, and hyperplasia of all the smooth muscle cells of the arterioles and bronchi are secondary phenomena.

The diffuse distribution of changes in the air spaces somewhat resembles that of asbestosis; in asbestosis, however, there is early sclerotic thickening of the alveolar walls; in our case, on the other hand, the thickening is only cellular, and sclerosis can be observed almost only where cellular proliferation has overwhelmed the alveolar architecture.

In the literature we know of only six anatomical records of pneumoconiosis from diatomaceous earth dust; these were described by Nordmann in 1943; they are quite different from ours, having the common features of quartz silicosis, with the only peculiarity that he found in the lungs diatomaceous fragments, either naked, or covered with sheets very similar to those of the curious bodies of asbestosis. The diatomaceous earth dust inhaled by Nordmann's workers was crude and contained large amounts of quartz and—in three cases—also asbestos. The fact that our patient had been working only with ignited and quite pure diatomite must be taken into account in interpreting the great difference in the findings.

Is it possible to consider the picture we have described as characteristic of the pneumoconiosis from ignited diatomaceous earth dust? On the basis of a single case such an affirmation would hardly be justifiable. But some considerations should be emphasized. The possibility that, as well as dust, a chronic infective process, tuberculosis, for example, might be involved in the ætiology of this case, can be ruled out by the negative clinical findings and the negative guinea-pig test with fibrotic lung tissue. The following morphological findings also counter such a view: the homogeneous diffusion and bilateral symmetry of the uniform granulomatous process; the lack of nodular structures and of evidence of exudative and caseous changes; the rather "foreign-body" appearance of the rare and isolated giant cells; and the constant association of granulomatous change with the presence of dust particles. If tuberculosis were involved, it would have to be an exceptional morphological modification of it produced by baked diatomaceous earth dust. But this is entirely a matter of conjecture.

The most remarkable and striking peculiarity of our case, in comparison with the well-known characters of quartz silicosis, is the prevalence of the phagocytic hyperplastic reaction of the tissues coming into contact with dust (that is, the walls of

lung air spaces and the lymphoreticular tissue of lymph nodes and spleen) giving rise to a granulomatous rather than a fibrotic type of silicosis.

X-ray Diffraction Studies

Severe cases of silicosis have been observed in two factories manufacturing diatomite filter candles. This fact is in contrast to the experiences of many writers who affirm that diatomite is not significant as a producer of silicosis, but may be explained by the fact that what has hitherto been studied is the effect of raw diatomite, or diatomite that has been dried up for a short time at 500 to 600° C. We, on the other hand, have examined workers exposed to the inhalation of diatomite calcined at 1250° C. for several hours. Crude diatomite is in fact considered as an amorphous variety of free silica, though Berkelhamer (1941) affirms that diatomaceous earth and opal, formerly considered truly amorphous, may give an *x*-ray diffraction pattern indicating some crystalline structure. Calcination is likely to cause a change in the physical structure of diatomite: this opinion was first put forward by Kyropulos, who in 1917 found that after calcination amorphous gelatinous silica produces an *x*-ray diffraction pattern indicative of tridimite; lately Durkan (1946) stated that calcined diatomaceous earth contains both amorphous and crystalline silica giving the *x*-ray pattern of cristobalite. These statements needed control to decide whether the great danger of calcined diatomite dust inhaled in making filter candles may be attributed to its crystalline form. We have therefore studied raw diatomite, and diatomite calcined at 1250° C., with the *x*-ray diffraction method. A Micro-Metalix apparatus with Debye-Scherrer equipment, and a Siemens apparatus with Laue equipment, were used for this purpose. Raw diatomite, as marketed and used in industry (mainly dried at 500 to 600° C.), showed no crystalline structure (fig 8a.) Diatomite calcined for three hours at 1250° C. in presence of coal and magnesite, as used for filter candles, showed an intense cristobalite pattern (fig. 8b). Purified diatomite with small quantities of electrolytes added, and heated at 900° C. for one hour, began showing the most intense line of the cristobalite spectrum; at the sixth hour of heating the intensity of the pattern reached its maximum. No tridimite pattern was seen in our experiments.

Therefore the diatomite silicosis seen in the filter-candle workers is a cristobalite micro-crystalline silicosis: refractory brick workers too are exposed to cristobalite dust in steel factories, although this cristobalite is macro-crystalline. There are, indeed, some analogies in the radiological aspect of silicosis by calcined diatomite and silicosis of masons in the furnaces of steel works. It is very likely that the different internal structure of crude and calcined diatomaceous earth dust is the cause of their differing liability to cause silicosis: this is the only reasonable explanation of why crude amorphous diatomite dust produces mild and seldom incapacitating silicosis, while calcined micro-crystalline diatomite dust is liable to produce severe and not infrequently fatal cases.

Conclusion

Several cases of malignant pneumoconiosis, two of which were mortal, have been observed in two factories manufacturing filter candles. The material employed contains 80 per cent. diatomaceous earth. Since the other constituents (alumina and ferric oxide) and the added magnesite have no fibrosis-producing action, the cause of the pneumoconiosis lies in the micro-crystalline silica content of the calcined diatomite, which gives the *x*-ray diffraction-pattern of cristobalite. Therefore, the term diatomite silicosis seems appropriate, although from a clinical, radiological, and pathological point of view this type of silicosis differs somewhat from the classical silicosis set up by quartz.

Bearing in mind that the small number of our observations does not allow definitive conclusions, the most important clinical features of the ignited diatomite dust silicosis appear to be:

1. A rather rapid development and severe course of the silicosis. Case 2 showed advanced silicosis after five years' exposure; case 3 died of silico-tuberculosis after seven years' work; case 7 had advanced silicosis after five years' exposure; case 8 died of silicosis after eleven years' work; the majority of workers showed radiological signs indicative of silicosis after four years' work in the candle-turning department.

2. A tendency—resembling what occurs in asbestosis—to general wasting in the advanced stages of the disease, although not complicated by infection. Case 7 weighed 42 kg; case 5 43 kg; case 6 39 kg; case 2 46 kg.

3. Tendency to spontaneous pneumothorax, owing to the presence of numerous emphysematous sub-pleural blebs, especially in the apex. Of seven cases of advanced silicosis, three cases showed a spontaneous pneumothorax, one of which was bilateral.

4. Absence of a typical nodular stage in the radiograph, as seen in classical simple silicosis, notwithstanding the high free silica content of the inhaled dust. The fibrosis set up by diatomaceous earth seems more diffuse than nodular. In the early stages it is finely reticular, the reticulation being sometimes sharp and lace-like, sometimes

blurred in appearance ; in the more advanced stages the reticulation is coarser, both because of the presence of thick strips leading toward the root lung, and the evidence of a perisclerotic and compensatory emphysema. In severe cases the shadows are patchy, irregularly shaped, sometimes fluffy ; the shadows are often conglomerated, and even massive in the subclavicular regions and in the middle fields, where the reticular and patchy design is sometimes obscured by a more or less extended blurred appearance, somewhat resembling ground glass.

Three cases showed markedly enlarged root and mediastinal lymph nodes.

In the only case that we have examined pathologically, the pathological changes gave a general impression of extraordinary intensity of formative stimulus possessed by the diatomite dust, which, through a very strong cellular reaction, set up a young and exuberant granulomatous tissue, diffuse in type, without nodular growths, and only partly transformed in dense fibrotic and hyalinized mass ; these changes, associated with marked emphysema, explain the particularly rapid course of the ignited diatomite silicosis.

The reason for the difference between the mild silicosis observed among the crude diatomite workers and the malignant silicosis observed among the ignited diatomite workers probably lies in the fact that the ignition at 1250° C. transforms the amorphous silicon dioxide of the crude diatomite earth into micro-crystalline cristobalite, which seems to be a very powerful silicosis-producing type of free silica.

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BOOK REVIEWS

PSYCHOLOGY. THE FUNDAMENTALS OF HUMAN ADJUSTMENT

By Norman L. Munn

(George G. Harrap. London. 1947. Pp. 497. Illustrated. Price 18*s*.)

Dr. Munn is a lecturer in Psychology in Tennessee. He has written a book indicating the foundations of the lectures which he gives, and a remarkably full book it is, ranging from Plato to Rorschach. It moves through the problems of feeling, emotion, cognition, and achievement to those of intelligence and personality. The emphasis is throughout upon the experimental method of the psychological laboratory, and diagrams and figures are abundant. Every chapter is followed by a bibliography.

The material presented is considerable, but it is all "potted." The small reproduction of Healy's picture-completion test in Fig. 203 seems valueless as it stands, and similar criticisms could be levelled at many other figures. Where Dr. Munn is discussing introversion and extroversion he again inserts a figure which is interesting, but he does not in the text really tackle the problems involved. This is typical of the information given: it is true up to a point, but it is doubtful if any student could rely satisfactorily upon learning any useful psychology from this volume alone. The mischief is that many students would consider that they could. We have no doubt that Dr. Munn knows these dangers better than the reviewer. This book reminds us of those medical primers "Aids to..." which are so compressed that at times they give information which could be falsely interpreted.

So long as Dr. Munn's book is recognized as an attempt to abbreviate an enormous subject and to stimulate further reading, well and good. But its danger lies in its being accepted too glibly as authoritative *per se*, and the simplicity of some of its diagrams illustrates these dangers only too well. As a form of suggestive notes to the teacher of psychology already well versed in the subject it has something useful to offer.

H.W.

THE NATURAL HISTORY OF DISEASE

By John A. Ryle

(Second Edition. Geoffrey Cumberlege. Oxford University Press. 1948. Pp. xiv + 484. Price 22*s*. 6*d*.)

The appearance of a second edition of this readable collection of essays and papers will be warmly welcomed. The work will be remembered as a well-balanced combination of sound teachings based on clinical observation, record, and analysis, written somewhat in the style of the physicians of a generation ago. It is, however, more than this because it links up with the future trend of developments in social medicine by references to the value of investigation of the natural history of disease not only in the individual patient, but also in the family, which is the smallest social unit, and so to larger populations in the community. In this light a new chapter on the social pathology of rheumatic fever has been introduced, in which the author supports voluntary notification, emphasizing the value this would have upon epidemiological and ætiological studies, the basis of further developments in preventive action. He remarks, however, on the modern tendency of doctors to become so interested in local pathologies that they forget the minds of their patients, and that anxiety is one of the most frequently encountered symptoms in practice and demands reassurance from the doctor. The drift towards prevalent neurosis in the community he attributes to our generation becoming too disease conscious. "It is possible to legislate too much for safety and for health, or, rather for a state of no disease which is not really health," he writes.

There are two further new chapters on nosophobia and prognosis. Wider use of statistical analysis is urged, implying the follow-up method, so that the physician can develop the important facility for accurate prognosis. The author makes no excuse for retaining his chapter on lobar pneumonia and explains that, although chemotherapy has greatly altered treatment, the lessons to be learned about judgment in prognosis cannot better be exemplified than by a study of the natural history of this disease. "Full notes, frequently perused, are the essence of clinical deduction." One feels that this is the text of the author's thesis throughout the book. A detailed history will time and again prove its value in the analysis of the meaning of symptoms. Medical students should read, and qualified doctors of all grades re-read this likeable book.

J.L.L.

PRINCIPLES OF MEDICAL STATISTICS

By A. Bradford Hill

(Fourth Edition. Lancet. London. 1948. Pp. 252. Price 10*s*. 6*d*.)

In view of the present dearth of textbooks, the reissue of Professor Bradford Hill's *Principles of Medical Statistics* is particularly welcome. It has already become a standard work, and the new sections included in the latest edition should greatly enhance its value. The book provides an excellent introduction to simple statistical methods of experimentation and analysis and, although the illustrations are all drawn from medicine, it should prove useful to workers in other fields as well. The author assumes no previous knowledge of the subject and confines himself to what may be termed "arithmetic guided by logic." The book covers the selection and presentation of data, averages and variability, sampling and correlation, life tables and the standardization of death rates. There is also a particularly useful section on common fallacies and the misuse of statistics.

All these subjects are treated to lucid discussion, and even those who are inclined to be terrified at the sight of figures should find it an easy book to read. At the same time, the author brings out the essential aspects of each problem and gives excellent advice to the uninitiated on most of the points on which they are liable to go astray.

It may seem ungenerous to offer any criticisms of a work of such high standard, but no two statisticians can expect to find themselves in complete agreement. One's only general criticism is that the author seems to go to unnecessary lengths in his understandable desire to avoid the use of symbols, even when giving the formula for a regression equation (p. 148). Surely no one would ever calculate a regression equation if he were incapable of using elementary symbols to represent the different variables. One has the impression, in fact, that much of the exposition could have been simplified, and would not have become any more difficult to follow, if conventional notations had been used.

The remaining criticisms are all on rather technical points. When it is necessary to divide patients into two groups, with the idea of giving a certain treatment to one group and not to the other, it is not a good general rule to allocate the patients, as suggested (p. 5), alternately to the two groups. Such an allocation is certainly not random and if the original order has any significance (for example, if it has a trend) the comparison of the two groups will be biased.

For testing the significance of the difference between two samples as regards the proportion of cases having a certain attribute, two methods are given, both of which are stated to be based on the hypothesis that the samples are drawn from the same universe. But the second method (pp. 111 to 112), is not very clearly set out; so that the estimates of the standard deviations appear to be, but are not in fact, dependent on this hypothesis. It should also have been made clear that the test depends on estimates, not true values, of the standard deviations.

A similar criticism may be made of the two methods suggested (pp. 114 to 115) for testing the significance of the difference between sample means. The second of these provides the more powerful test for detecting the existence of a real difference; the first appears to have no particular merit. Both tests apply only to large samples and it might have been better to give the *t* test, which is uniformly most powerful and is really no more difficult to use.

The method proposed (pp. 152 to 153) for testing the significance of a correlation coefficient is not to be recommended. In the only example quoted, the method is correctly used for testing whether the correlation coefficient differs from zero. But it should have been emphasized that the formula for the standard deviation of *r* (the sample value of the correlation coefficient), and the assumption that *r* is normally distributed, are valid only if the true correlation is small and if the sample is large (100 or more). When giving this method, the author specifically refers to "relatively small samples"; but in small samples, as R. A. Fisher has shown, the distribution of *r* is far from normal. We read only later on, almost as an aside, that "somewhat more intricate methods are needed for small samples and to test whether one coefficient differs 'significantly' from another." In fact, it is easy to find out whether the correlation coefficient differs from zero with the help of a table given in Fisher and Yates's *Statistical Tables*. The term "small" should, of course, be clearly defined, especially when it has quite a different meaning from "relatively small."

In the section on death rates, mention might have been made of the Life Table death rate, which is probably to be preferred to the standardized death rate. It is also a little odd to find a table of χ^2 and no table even of the Normal Curve.

But none of these weaknesses, some of which may be due to faults in phrasing, can affect the undoubted merits of the work as a whole. *J.L.N.*

AN INTRODUCTION TO MEDICAL STATISTICS

By H. M. Woods and W. T. Russell

(Second Edition. Staples Press. London. 1948. Pp. 125. Price 8*s.* 6*d.*)

This book by Woods and Russell, which is more elementary than Professor Bradford Hill's, is also a very useful introduction to medical statistics, suited to the needs of people studying for the Diploma of Public Health. Plenty of examples are fully worked out and the exposition throughout maintains a high standard of clarity. The only faults which can be found are in the diagram illustrating the weekly incidence of infectious diseases (Diagram VII, p. 26), which is very muddled in appearance; and in the list of books for "further reading," which is sadly out of date. *J. L. N.*

ABSTRACTS

(This section of the JOURNAL *is published in collaboration with the two abstracting journals, Abstracts of World Medicine, and Abstracts of World Surgery, Obstetrics, and Gynæcology, published by the British Medical Association. The abstracts are divided into the following sections: toxicology; industrial physiology; industrial lung disease; industrial dermatitis; accidents and orthopædic surgery; environment; general.)*

TOXICOLOGY

British Anti-lewisite. A Report on its Use and Therapeutic Value in Arsenical Intoxications, from the BAL Conference, Medical Research Council. PETERS, R. A., BENNET, J., KING, A. J., CARLETON, A. B., DIXON, M., CAMERON, G. R., GADDUM, J. H., HERRALD, F. J. C., MCELLIGOTT, G. L. M., OWEN, L. N., STOCKEN, L. A., WILLIAMS, D. I., FINDLAY, H. T., and THOMPSON, R. H. S. (1947). *Brit. med. J.*, **2**, 520.

This report by the Medical Research Council of the clinical assessment of BAL in arsenical dermatitis confirms work already reported in Britain and U.S.A. The clinical material consisted of 44 cases, of which 41 were of the acute exfoliative type; 5% BAL in arachis oil and benzyl benzoate sterilized by heat and sealed over nitrogen was given in doses of 1·5 mg. per kilo intramuscularly into thigh or gluteal muscles. An average course was as follows: first day, 4 injections of 2 ml. at 4-hourly intervals; second, third, and fourth days, 2 ml. twice daily; fifth and sixth days, 2 ml. daily. Thirty-one of the 44 cases were benefited, 23 (52%) strikingly so. The average time of healing was 21 days, and subsidence of skin œdema was an early sign. Clinical relapse was sometimes seen; this responded to a second course.

The minimum dose which causes toxic signs (these appear trivial) lies between 3 and 5 mg. per kilo. In America 6 doses 4-hourly of 3 mg. per kilo have been given on the first day to severe cases. It is considered, on the basis of animal experiments, that hepatic damage but not renal damage increases toxicity, but does not contraindicate the use of both. Post-arsphenamine hepatitis of infective origin is outside the scope of action of the drug. Local abscess formation at the site of injection is considered to arise from skin infection in cases of exfoliative dermatitis of long standing. Reference is made to favourable reports, published elsewhere, on the use of BAL in cases of arsenical encephalopathy and granulocytopenia. The successes reported in acute mercury poisoning and in gold intoxication are also noted. [There is a valuable bibliography.]

G. Brownlee.

BAL-intrav; A New Non-toxic Thiol for Intravenous Injection in Arsenical Poisoning. DANIELLI, J. F., DANIELLI, M., FRASER, J. B., MITCHELL, P. D., OWEN, L. N., and SHAW, G. (1947). *Biochem. J.*, **41**, 325.

This substance, a soluble glucoside of BAL, was prepared from allyl glucoside by acetylation to tetra-acetylallyl glucoside, which was "brominated, treated with potassium thioacetate, and saponified." The product was not chemically pure but had less than $\frac{1}{100}$ of the toxicity of BAL and prevented death in 100% of mature rabbits when given 6·5 hours after three median lethal doses of lewisite. In young rabbits (600 g.) earlier treatment was necessary. A number of other BAL derivatives were prepared, but the glucoside proved to be the least toxic and most effective. Throughout the series toxicity decreases with increasing polarity of the molecule.

V. J. Woolley.

The Fate of Arsenical Vesicants in the Skin and the Effect of BAL (British Anti-lewisite). GRAHAM, A. F., LEVVY, G. A., and CHANCE, A. C. (1947). *Biochem. J.*, **41**, 352.

Lewisite (β-chlorovinyldichloroarsine) or phenyldichloroarsine was applied as a drop to the dorsal skin of a rabbit and left for varying periods up to 168 hours. Some of the latter but none of the lewisite disappeared by evaporation. Immediately on application part of the arsenic became so fixed in the skin that it could not be extracted by acetone, but local application of BAL made all the arsenic extractable. This effect did not follow intravenous injection of BAL, nor did BAL affect the rate at which absorption from the skin into the circulation occurred.

V. J. Woolley.

Studies on the Toxicity of Inhaled Cadmium. I. The Acute Toxicity of Cadmium Oxide by Inhalation. BARRETT, H. M., IRWIN, D. A., and SEMMONS, E. (1947). *J. industr. Hyg.*, **29**, 279.

Animals were exposed, in a chamber with a capacity of 555 litres, to fume generated by striking an arc between a carbon projector rod and a lump of metallic cadmium. Electron microscope photographs showed the fume to be made up of particles of from 0·3 to 0·5 μ in diameter. The LD 50, measured in minute-mg. per cubic metre, was 500 in rats, probably about the same in mice, 2,500 in rabbits, 3,500 in guinea-pigs, 4,000 in dogs, and 15,000 in monkeys. The amount of cadmium-oxide fume retained by the lungs of the animals killed was found to be remarkably constant, and from calculations of the lung ventilation rate it was estimated to average 11% of that inhaled. From analyses made by previous investigators of the lung content of cadmium oxide in 2 men who died as the result of an industrial exposure, it was calculated that the lethal dose for man is 2,500 minute-mg. per cubic metre.

H. M. Vernon.

Studies on the Toxicity of Inhaled Cadmium. II. The Acute Lethal Dose of Cadmium Oxide for Man. BARRETT, H. M., and CARD, B. Y. (1947). *J. industr. Hyg.*, **29**, 286.

In order to determine the lethal dose of cadmium oxide for man, experiments were made in a Canadian factory under conditions of exposure resembling those which, in 1938, resulted in 2 deaths. They were made in the

same plant, in a room 130×23×11 ft. The same annealing furnace was in operation, and 300 lb. of rivets of the same dimensions as before were put through it. They contained 1·85% of cadmium. Several windows were open during the fatal operation, but in order to make the conditions as severe as possible only two were kept open in two of the present trials, and none in two others. Air samples were collected at 18 or 26 sampling points, and at some of these positions cages of rats or rabbits were placed. Personnel engaged in the trials wore Canadian Army respirators. The emission of fume from the furnaces lasted 20 to 25 minutes. When all windows were shut all the exposed rats and about half the rabbits died. When two windows were open, more than half the rats died. Men who had been present at the time of the fatal accidents thought that the visibility was greater than in the present test in which two windows were open. In this test the peak dosage was found to be 2,900 minute-mg. per cubic metre, so this must be considered lethal for man. The fume produced in the plant was less than half as toxic for rats as arc-produced fume; hence it is possible that in man a lethal dose of the arc product is not more than 1,500 minute-mg. per cubic metre. *H. M. Vernon.*

Studies on the Toxicity of Inhaled Cadmium. III. The Pathology of Cadmium Smoke Poisoning in Man and in Experimental Animals. PATERSON, J. C. (1947). *J. industr. Hyg.*, **29**, 294.

The human material for this investigation was obtained from the 2 fatal cases studied in 1938 by Bulmer, Rothwell, and Frankish. For the animal material, rats, rabbits, and goats were exposed in a 10-cubic-metre chamber to fumes of cadmium oxide or of cadmium chloride.

About 25% of the animals surviving exposure to doses of cadmium large enough to produce symptoms showed a significant degree of residual pulmonary fibrosis, and there is some likelihood that similar fibrosis would be present in men who survive large doses of cadmium fumes. The upper limit of dosage to which rats may be exposed repeatedly without causing fibrosis was determined, and in the light of these results it is considered that a cadmium-oxide concentration of 0·1 mg. per cubic metre of factory air would give an adequate margin of safety to industrial workers. *H. M. Vernon.*

The Effects and Treatment of Inhalation of Cadmium Chloride Aerosols in the Dog. NARRISON, H. E., BUNTING, H., ORDWAY, N. K., and ALBRINK, W. S. (1947). *J. industr. Hyg.*, **29**, 302.

Air was circulated through a 850-litre chamber at the rate of 500 l. per minute, and a 25% solution of cadmium chloride was sprayed into the air intake of the chamber into which 2 dogs had been placed. Atomization was continued for 30 minutes, and 10 minutes more were required for flushing out the chamber. One animal was then treated and the other reserved as a control. The experiment was repeated several times. The dogs showed salivation and vomiting, with rapid respirations and an initial slowing of the heart, followed by acceleration. A number of the animals rapidly developed pulmonary œdema, and died in a few hours or days. Rapidly developing hæmoconcentration was associated with the œdema and an equally rapid decrease in arterial oxygen saturation. The anoxæmia resulting from the pulmonary injury was the primary cause of death.

In a number of the dogs, 2,3-dimercaptopropanol (BAL) was administered immediately after exposure or 60 minutes later. The results indicated that the more effective treatment is the largest safe dose of BAL that can be administered in the shortest possible period after exposure to cadmium inhalation. Continued treatment after the first day is probably of no value; neither is the application of a 5% BAL ointment inunction.

The early pathological changes consisted of necrosis of the lining epithelium of the lungs, particularly of the bronchioles, and of the underlying smooth muscle. Later, a polymorphonuclear exudate appeared in the bronchi and bronchioles; bacterial pneumonia was only occasionally observed. *H. M. Vernon.*

A Study of Industrial Exposures to Cadmium. PRINCI, F. (1947). *J. industr. Hyg.*, **29**, 315.

The 20 workers employed in a cadmium smelter were examined repeatedly over a period of 3 months. They had been exposed for a period of 6 months to 22 years, but had no illnesses which the plant physician believed to be due to cadmium. Air samples taken at the breathing level in the eleven operations to which these men were likely to be exposed showed that in the cadmium-sulphide packaging room the average atmospheric concentration was 31 mg. of Cd per cubic metre of air, while in two other operations it was 19 and 17 mg. respectively. Many of the men were constantly covered with cadmium-sulphide or oxide powder, and they seldom wore the respirators provided or washed before eating. The only definite clinical symptom was the appearance of a yellow ring at the base of the teeth in several of the men. The ring began at the gingival margin, and extended about half-way down the tooth, the colour varying from light yellow to golden brown. The ring did not appear in workers with less than 2 years' exposure. Complaints of constipation, weakness, and headache were made by several of the men; 4 reported poor appetites, and 2 showed loss of weight, but none of these symptoms was incapacitating. The blood and urine always contained cadmium, the average per 100 g. of blood ranging from 0·010 to 0·065 mg., while the urine contained from 0·010 to 0·139 mg. per litre. In neither case did the figures show any relation to the degree of exposure. There was no evidence of an increase of red blood cells. Lymphocytes were increased, but leucocytes were within normal limits.

Most of the deleterious effects of cadmium hitherto reported have been the result of relatively brief exposures to high concentrations of the substance, but it is probable that in chronic exposures there is a rapid elimination of the cadmium from the body, and that there is no cumulative effect. The author thinks his data suggest that cadmium may not be so great an industrial hazard as has previously been reported. [It will be noted that this conclusion differs greatly from that arrived at by Paterson (see abstract in opposite column).] *H. M. Vernon.*

The Possibility of Chronic Cadmium Poisoning. HARDY, H. L., and SKINNER, J. B. (1947). *J. industr. Hyg.*, **29**, 321.

In a factory engaged in the manufacture of cadmium-faced bearings the cleaned cylinders were submerged in a well-ventilated cadmium pot at a temperature of 800° to 850° F. (428° to 456° C.), and were given other treatment with molten cadmium. Air samples taken over a period of years contained an average of 0·11 to 0·34 mg.

of cadmium per cubic metre of air, with a maximum of 0·68 mg. The average amount present was probably about 0·1 mg. per cubic metre. Clinical records of 5 of the 8 men engaged in the work for periods of 4 to 8 years revealed complaints of fatigue, dental trouble, gastro-intestinal symptoms, and, on damp days, respiratory symptoms. The blood of 2 of the men showed only 70% of hæmoglobin on the Sahli scale. The mean amounts of cadmium in the urine varied from 0·1 to 0·05 mg. per litre. *H. M. Vernon.*

Industrial Selenosis. A Review of the Literature, Report of Five Cases and a General Bibliography. BUCHAN, R. F. (1947). *Occup. Med.*, **3**, 439.

Selenium is used in a variety of industrial operations, and in certain combinations is capable of producing acute and chronic effects. Animal experiments have demonstrated that ingestion or inhalation of selenium compounds produce damage in the liver and other organs. Reported cases of industrial or occupational selenosis are not numerous, although it is to be expected that many have occurred. Cases of occupational dermatitis, and also of irritation of the upper respiratory tract and gastro-intestinal disturbances, have been ascribed to selenium poisoning. The author gives an historical review of the toxicological effects of selenium, with numerous references. Selenium may be ingested, inhaled, or absorbed through the skin. Excretion may be through the lungs or in the urine and the fæces.

A report is given on 5 cases of selenium intoxication arising from an industrial hazard; it indicates the need for thorough investigation in considering complaints of obscure causation in workers. The patients were exposed to less than 0·2 part per million of hydrogen selenide. Predominating symptoms were nausea, vomiting, metallic taste in the mouth, alliaceous breath odour, dizziness, and extreme lassitude and fatigue. Urinary excretion levels were indicative of absorption of selenium and decreased after exposure ended. Present evidence does not indicate any satisfactory method of deselenization.

Prevention of industrial selenosis is dependent on an intelligent appreciation of the inherent hazards attached to the use of selenium products, and on proper engineering and medical control. It is suggested that all workers potentially exposed be examined at intervals, after a preliminary replacement examination. Careful attention should be given to complaints referable to the respiratory tract, the gastro-intestinal tract, and the central nervous system. Routine periodic examination of urine for evidence of absorption of selenium should be made. *A. Thelwall Jones.*

Experimental Selenium Poisoning. (Intossicazione sperimentale da selenio.) VESCE, C. A. (1947). *Folia med., Napoli*, **33**, 209.

Reference is made to the work of Madison, of Missouri, who in 1856 described cases of selenium poisoning in man and animals occurring in that State. The author considers that the poison takes particular effect on the endocrines. It is pointed out that the discovery of selenium in the urine is not, in itself, evidence of poisoning. It may occur in workers handling such materials as lead, zinc, pyrites, lime, and cement. As much as 5 mg. has been found daily in the urine for a week without the appearance of toxic symptoms. Inorganic selenium compounds are rapidly eliminated, so that in a week from 80 to 90% may pass out in the urine and small quantities in the fæces. Organic selenium compounds behave very differently and are retained much longer. They are found in fairly large amount in the liver, spleen, kidneys, pancreas, heart, and muscles. Smaller concentrations are found in the nervous system and the bones. Selenium may be excreted for 6 months after a period of exposure.

The author gave guinea-pigs sodium selenide by the mouth, 5 mg. daily for 20 days and then 12·5 mg. daily for 20 days. Those which survived were killed 40 days later. At necropsy the changes in the ovaries and suprarenals were marked. The suprarenal cortex was particularly affected, but in the medulla also degenerative changes were seen, which sometimes took the form of large hæmorrhagic areas. The process of ovulation was disturbed. The pars anterior of the pituitary was found to contain scattered œdematous or hæmorrhagic areas. The thyroid was shrunken but otherwise little altered. In the pancreas changes of hypertrophic type were seen, and it appeared that the islets had been exposed to constant stimulation. The changes described were noted in all the animals examined. The author suggests that the changes in the pituitary explain many of the findings in other organs by reason of the widespread endocrine disturbance caused. He emphasizes that a high urinary output may not indicate safety since the organic compounds are more harmful, and are excreted much more slowly, than the inorganic ones.

G. C. Pether.

Experimental Study of Nickel Poisoning. (Ricerche sperimentali sull'intossicazione de nichelio.) CERESA, C. (1947). *Med. d. Lavoro*, **38**, 225.

The effect of subcutaneous injections of nickel sulphate in guinea-pigs was investigated. A dose of 10 mg. was given daily and was well tolerated, no animal dying from poisoning. Various groups of animals were killed and blood examinations carried out at intervals. No changes were noted in the chloride or calcium content of the blood. Blood sugar rose after the injections, and blood urea slightly. There was a fall in hæmoglobin and an increase in red cells after fairly lengthy periods, and a slight leucocytosis. In the bone marrow there was an increase in basophil erythroblasts, metamyelocytes, and polymorphonuclear cells. At necropsy no characteristic lesions were found but the metal was identified in the brain, heart, lungs, liver, spleen, kidneys, suprarenals, and pancreas. The metal is eliminated only by the kidneys up to the fourth day. After this, it is also eliminated by the bowel but renal elimination remains greater than fæcal. *G. C. Pether.*

Manganese Dioxide as an Antidote to Mercury. (In Russian.) PEREGUD, E. A. (1947). *Gigiena*, **5**, 19.

Many attempts have been made by different means to fix the fumes of mercury, but until recently no satisfactory agents have been described. In 1933 Alexeef proposed the use of active manganese dioxide as this quickly forms an amalgam with mercury. It is suggested that the active dioxide could be employed in order to protect the respiratory organs and to free contaminated spaces of fumes. In a suitable base it could be utilized to fill cracks through which mercury might escape. It was also found that non-activated manganese dioxide in various strengths of hydrochloric acid might be used with advantage. It forms an oxidized film on the surface of the mercury and as a result there is a rapid loss of surface tension. Hydrochloric acid in suitable amount and concentration assists this reaction.

G. C. Pether.

The Control of Lead Exposure in Storage Battery Manufacture. WINN, G. S., and SHROYER, C. (1947). *J. industr. Hyg.*, **29**, 351.

During the past 10 years (1936–45) frequent improvements have been made in working conditions to control lead exposure in a factory devoted to battery production, and as a result only 4 cases of lead intoxication have been reported among the 300 men exposed to risk. New employees are subjected to a thorough investigation, including chest radiography, blood count, and physical examination. The men are carefully instructed about personal hygiene, and potential hazards are pointed out. At monthly intervals the lead-dust in the factory air is determined at 35 to 50 points. All workers in potentially hazardous positions report periodically to the hospital, and blood checks are made at intervals of 14 to 60 days. Averages taken of the 115 men who worked more or less continuously over the 10-year period showed that there was close correlation between the stippled cell count and the percentage of hæmoglobin, but there was no corresponding relation between these values and the erythrocyte counts. The curves for the concentration of lead-dust in the air showed the improvement produced after 1942 by the installation of new exhaust systems. It is considered that the maintenance of an average of not more than 5 mg. of lead per 10 cubic metres of air affords adequate control. Analyses of urine samples indicated that 0 to 150 μg. of lead per litre is the normal range for men working under controlled conditions. The range of 150 to 250 μg. is abnormal, and the workers involved should be kept under observation until the cause is identified and corrected. Whenever excretion exceeds 250 μg. steps should be taken immediately to reduce the lead intake—for example, by transferring the workers to a position of minimum exposure. *H. M. Vernon.*

Estimation of Pyridine in Air. (Učrování pyridinu ve vzduchu.) FIŠER, K. (1947). *Čas. Lék. čes.*, **86**, 1189.

A number of known methods to determine the concentration of pyridine in the air (Schutze's titration method, colorimetric methods with chloramine, β-naphthylamine, 2,4-dinitrochlorobenzene, benzidine) were tested. The best results were obtained with a slight modification of the benzidine method, which permits the detection of 5 μg. of pyridine per litre of air and even less. Urine examination of the affected persons did not show the presence of pyridine. *J. Ungar.*

Mild Poisoning due to Pyridine. (Lehké chronické otravy pyridinem.) TEISINGER, J. (1947). *Čas. Lék. čes.*, **86**, 1185.

Symptoms of mild chronic intoxication with pyridine vapour—intensive headache, transient dizziness, irritability, and sleeplessness—occurred in 7 workers in a chemical factory. Occasionally digestive troubles, especially nausea and vomiting, impaired memory, and lack of concentration were observed. On clinical examination no abnormalities were detected except a marked lymphocytosis in 2 of the patients. The author considers that through faulty ventilation a mild chronic intoxication with pyridine vapour and ammonia occurred in the factory over a period of 2 to 3 years. Pyridine was demonstrated in the aspirated air in concentrations of 20 to 40 μg. per litre; these should be regarded as toxic. *J. Ungar.*

Epidermal Application of Diethylene Glycol Monoethyl Ether (Carbitol) and some other Glycols. Absorption, Toxicity, and Visceral Damage. HANZLIK, P. J., LAWRENCE, W. S., FELLOWS, J. K., LUDUENA, F. P., and LAQUEUR, G. L. (1947). *J. industr. Hyg.*, **29**, 325.

Carbitol is used extensively in cosmetics and industrial products, and is generally assumed to be innocuous. It is easily absorbed by the skin, and a few isolated observations by various workers suggest that it may have a toxic action. Rats failed to show ill-effects after the application of 8 to 16 ml. of carbitol per kilo daily for 2 months, so 286 rabbits were tested.

The pathological changes observed after repeated applications of the higher doses of carbitol (0·16 ml. per kilo and upwards) were microscopic and functional lesions of the kidney, but smaller doses caused only functional impairment, and 0·04 ml. per kilo caused no demonstrable injuries. The results appear to indicate that for human beings there are definite health hazards in the indiscriminate and uncontrolled use of products containing high concentrations of carbitol, but a daily dose of 0·04 ml. per kilo should be reasonably safe.
H. M. Vernon.

Papilloma of the Renal Pelvis in Dye Workers: Two Cases, One of which shows Bilateral Growths. MACALPINE, J. B. (1947). *Brit. J. Surg.*, **35**, 137.

Two cases of papilloma of the renal pelvis in dye workers are reported in detail. In the first case the patient had been under treatment for a long time for multiple and massive bladder papillomata, and he was later found to have a papillary growth of the right kidney. This renal neoplasm was regarded as being a separate primary growth. In the second case the patient had what were regarded as three primary growths, a small papilloma of the bladder, a papillary growth in an atrophic left kidney, and a massive one on the right-hand side. Both renal neoplasms apparently developed after the bladder growth had been destroyed. The author states that the question of the occurrence of papillomatous disease of the upper urinary tree in dye workers has often been raised, but these cases were the first and only ones seen by him. A search of the literature has shown that only 6 other examples of pelvic papillomata in dye workers have been recorded.
W. G. Gill.

An Improved Method for the Determination of Volatile Halogenated Hydrocarbons in Blood and Other Biological Materials. ALFORD, W. C. (1947). *J. industr. Hyg.*, **29**, 396.

A method for the determination of halogenated hydrocarbons in blood was published by Moran (*J. industr. Hyg.*, 1943, **25**, 243), but his method is not suitable for tissue analysis. In the procedure described here the volatile halide is removed from an oil-water mixture by combined steam distillation and aspiration, and is decomposed in a heated platinum tube. The resultant inorganic halide is absorbed in an alkaline arsenious oxide solution, and estimated by a standard procedure. The apparatus consists of a 250-ml. distillation flask with a side-arm extending to within 0·5 cm. of the bottom of the flask. It is heated by a rheostatically controlled oil bath, and the vapour and steam pass through a reflux condenser to the combustion tube of platinum, which is 30 cm. in length and has a bore of 2 mm. packed with fine platinum gauze. It leads to the halogen absorption

tube of 35-ml. capacity, connected with a suction pump. Blood (oxalated) and tissue samples are stored under 15 ml. of mineral oil in stoppered tubes, which are well shaken. One hour from the time the mixture reaches boiling point is allowed for removal of the halogenated hydrocarbon from the sample. Analyses are recorded of various halogenated hydrocarbons, having boiling points ranging from 40° to 146° C., and they show an average error of only ±1·8%. *H. M. Vernon.*

A Study of the Efficiency of Methods for Obtaining Vapor Samples in Air. ANDREWS, H. L., and PETERSON, D. C. (1947). *J. industr. Hyg.*, **29**, 403.

The present report describes improved methods for obtaining vapour samples when studying toxic effects. The tests were carried out with benzene and xylidine, as their concentration can be readily estimated by ultra-violet spectroscopy. The Beckman quartz spectro-photometer was used, and the concentrations were determined by dissolving the vapour samples in *iso*-octane and measuring the optical density of a 1-cm. length of solution. The most sensitive band for benzene is at 255 mμ, and for xylidine 289 mμ. The apparatus for producing the vapours consisted of a 30-litre pyrex bell jar connected with a compressed-air supply equipped with an oil trap and calcium chloride drying tubes to remove moisture. The glass bubbler containing the hydrocarbon to be vaporized was kept at constant temperature, and was weighed before and after the test. In another method of sampling the vapours were drawn directly from the chamber into evacuated Shephard flasks ; in a third method, which was more suitable for low concentrations, two all-glass midget impingers were used in series. They contained *iso*-octane, and a measured volume of the chamber atmosphere was drawn through them at a rate of 0·2 litre per minute. The concentrations employed for the study of benzene ranged from 57 parts per million (p.p.m.) to 1,140 p.p.m. and of xylidine, from 50 to 100 p.p.m. The tables of test results show that the average loss of samples due to handling was less than 10%. *H. M. Vernon.*

Use of Plastic Chips in the Control of Chromic Acid Mist. MOLOS, J. E. (1947). *Industr. Med.*, **16**, 404.

Until recently control of chromic acid mist in the workers' breathing zone above chromium-plating tanks used in the electroplating industry was effected largely by means of local exhaust ventilation, but this, while effective, results in a considerable loss of chromic acid through the exhaust system. A newer practice is the surface application of plastic chips. The essential requirements for material used in this way are : (1) the solid particles must be able to float on the surface of the chromium-plating bath ; (2) the particles must not be affected by such physical conditions of heat and electricity as exist in chromium-plating tanks ; (3) the material must be inert chemically to all substances encountered in the plating solution. Many plastics fulfil these requirements.

A field test conducted at the Naval Air Station, Pensacola, Florida, to determine the effectiveness of one type of plastic-chip covering is described. With a 60-minute sample, taken 8 in. above the liquid surface and 4 in. from the anode, with an exhaust ventilation rate of 170 cubic feet of air per square foot (5 m.³ per 1,000 cm.²) of surface area, the average atmospheric concentration of chromic acid obtained with the use of spray-reducer chips was found to be 0·2 to 0·5 mg. per 10 cubic metres of air. Under exactly the same conditions but without spray-reducer chips, 45 to 50 mg. of chromic acid per 10 cubic metres of air was found. A 15-minute sample, taken under the original conditions but without the provision of exhaust ventilation, indicated an atmospheric concentration of chromic acid in the operator's breathing area ranging from 160 to 170 mg. per 10 cubic metres. Comparative results of tests carried out by the Udylite Corporation show an inverse relation between the blanket thickness of the chips and the atmospheric concentration of the chromic acid.

All tests made on electroplating plants in St. Louis under conditions where plastic chips were used as well as exhaust ventilation showed no chromic acid concentration whatever in the workers' breathing zone. Among a limited number of tests conducted at plants operating under conditions where plastic chips were used in the absence of local exhaust ventilation, was one plant where the worker's exposure to chromic acid mist varied from 19 to 30 mg. per 10 cubic metres. Such figures offer strong support to the contention that local exhaust ventilation should be provided for chromium tanks whether plastic chips are used or not. *A. J. Amor.*

INDUSTRIAL PHYSIOLOGY

Nephritis in Textile Workers. PLATT, R. (1947). *Brit. med. J.*, **2**, 771.

The evidence for a statement made in a leading article in the *British Medical Journal* (1947, **1**, 727) " that the inhalation of textile dusts is a steady source of death from nephritis and a group of conditions whose common factor is hyperpiesia " is examined. From critical review of the original figures—the Registrar-General's Decennial Supplement for 1931—it is found that these deaths from so-called nephritis in textile workers are in all probability due to hypertension, and can be as easily explained by natural variations in the genetic constitution of an inbred population as they can by environmental influences.

L. H. Worth.

Physiological Effects of Alkyl Polyphosphates. BURGEN, A. S. V., KEELE, C. A., CHENNELLS, M., CASTILLO, DEL J., FLOYD, W. E., SLOME, D., and WRIGHT, S. (1947). *Nature, Lond.*, **160**, 760.

Hexaethyltetraphosphate and tetraethylpyrophosphate, used by the Germans as insecticides, have physiological and toxic effects. Hexaethyltetraphosphate, largely hydrolysed in water into simpler bodies, in doses of 1 to 3 mg. per kilo, causes hyperexcitability, twitching, salivation, and convulsions. Progressive sensitization to acetylcholine was seen in isolated frog rectus, rabbit heart, and gut. The potentiation caused by concentrations of 2×10^{-5} to 2×10^{-6} M. lasted for 6 hours despite repeated washing out. Rhythmic contractions of the gut were increased, also tone (effect initially annulled by atropine). Tetraethylpyrophosphate had similar effects, but they were more transient. In the cat anæsthetized with chloralose gradual increase of dose from 0·25 to 2 mg. per kilo caused bradycardia, lowering of blood pressure, increased salivation, bronchial secretion, convulsions, defæcation, and death. The effect of peripheral vagus stimulation was only increased by 10 to 40%, but the recovery period was much prolonged. With large doses the vagus response was lost. In the cat under the influence of chloralose and atropine intravenous doses of 0·5 mg. per kilo had a well-marked

potentiating action on the response of muscles to stimulation of the popliteal nerve. Electrically a repetitive response developed with slightly asynchronous discharge. The last-mentioned dose had very little effect on blood pressure. Initial potentiation of spinal reflexes, increase of extensor tone, and convulsions were observed. Similar reactions were produced by intrathecal injection, with increased "repetitive knee-jerk," crossed extensor reflex, and mild convulsions. Violent convulsions occurred with a dose of 4 mg. per kilo and increased knee-jerk, suggesting slight absorption into the circulation. *D. T. Barry.*

The Treatment of Decompression Sickness; An Analysis of One Hundred and Thirteen Cases. VAN DER AUE, O. E., DUFFNER, G. J., and BEHNKE, A. R. (1947). *J. industr. Hyg.*, **29**, 359.

The chief objective in the treatment of decompression sickness is the rapid restoration of normal blood supply by immediate recompression. This reduces the size of the gas emboli and of bubbles in the tissues in proportion to the pressure applied. The treatment developed by workers at the Experimental Diving Unit and the Naval Medical Research Institute, Washington, involved three basic principles: (*a*) the limitation of the maximal pressure applied during recompression to 65 lb. per square in., and the maintenance of this pressure for 30 to 120 minutes; (*b*) a prolonged recompression for periods of 12 to 24 hours at pressure levels equivalent to depths between 30 and 60 ft.; and (*c*) the inhalation of oxygen at pressures equivalent to 60 ft. or less in order to promote the more rapid elimination of nitrogen. This treatment was applied to 113 divers who developed decompression sickness, and in 109 of them the treatment was successful. In the other 4 symptoms recurred after treatment. Of the 75 patients given oxygen, 4 developed mild symptoms of oxygen toxicity which were relieved promptly when the oxygen was discontinued.

The divers tested had worked for 1 hour under water in a pressure diving tank at a pressure equivalent to a depth of 130 ft. After decompression according to standard Navy tables they seldom developed decompression sickness, but among those who did 107 had localized pain, 10 numbness, 10 muscular weakness, 8 visual disturbances, 4 vertigo, and 2 aphasia; there were 2 cases of unconsciousness. In about a third of the men the symptoms appeared within an hour after decompression, in half of them within 1 to 6 hours, and in the remainder, at any time up to 24 hours after decompression. *H. M. Vernon.*

Fainting and Flying. An Analysis of 500 Cases of Impairment of Consciousness in Pilots and Aircrew. ROOK, A. F. (1947). *Quart. J. Med.*, **16**, 181.

The author reviews 500 consecutive cases of impaired consciousness among pilots and aircrew. The definition includes complete loss of consciousness, with or without convulsions, sudden disturbances of awareness, amnesia, confusion, and transient giddiness.

The cases are classified as neurogenic, cardiovascular, and emotional. In practice these three groups overlap, and it may be difficult to decide whether loss of consciousness is caused by epilepsy, syncope, or psychogenic factors. The neurogenic group formed just under a quarter of the cases; epilepsy was the causative factor in about half of these. The part played by fear in initiating an epileptic attack is stressed. The cardiovascular group comprised rather more than a quarter of the total. Cardiovascular inefficiency was the major causative factor, either alone or combined with contributory factors, such as infection or fatigue. The author discusses the significance of hypotension in aviators. In the Royal Air Force the lower limits of normality for systolic and diastolic blood pressures are taken as 110 and 70 mm. Hg respectively. It is considered that a single finding of hypotension according to these standards is comparatively frequent in young adults; although this condition is usually compatible with health, it indicates an increased liability to fainting. The remaining cases, which formed about a half of the total, were classified as emotional. In this group loss of consciousness was associated with anxiety and inability to stand up to the stress of flying. A combination of fatigue and anxiety was frequently present. Other ætiological factors encountered in the emotional group were panic state, hysteria, and simulation.

The author considers that the history of the patient is the most important single factor in examination, and that flying should be prohibited at once for those who have had two or more recent attacks of loss of consciousness. [The unique opportunity of which the author made use in collecting these cases and the lucidity of style and logical presentation will make this article a classic.] *R. Winfield.*

INDUSTRIAL LUNG DISEASE

Solubility Theory of Silicosis. A Critical Study. KING, E. J. (1947). *Occup. Med.*, **4**, 26.

The solubility of quartz dust in buffered Ringer solution increases as the particle size gets smaller; whatever the size of the particles, however, there is a progressive diminution in solubility after repeated treatment with the solvent. With particles down to 1 μ there seems to be an increased rapidity of fibrous-tissue formation in the lungs of rats with diminution in particle size, although the experiments detailed here are not very conclusive. No differences in solubility or pathogenicity of racemic, dextrorotatory, or lævorotatory quartz were detected. A sample of silica of extremely fine particle size was very soluble in Ringer solution, and killed rats rapidly when injected in large amounts; smaller quantities did not produce fibrosis after injection into the trachea.

The addition of 1% of any of four different brands of alumina to the samples of quartz lowered the solubility of the latter to a considerable degree. Intratracheal injection of such mixtures was, however, followed by fibrosis in the lungs of rats.

The silica in a sample of powdered sandstone containing 70% of quartz was only slightly soluble in buffered Ringer solution; this material, however, was almost as effective as pure quartz in producing fibrosis in the lungs of rats. On the other hand, a powdered shale containing 8% of quartz had a silica solubility between those of the sandstone and pure quartz, but produced very little fibrosis in experimental animals. Olivine, which is a magnesium silicate, had a medium silica solubility in small-particle size, and produced only slight fibrosis in the lungs of rats.

It may be that siliceous dusts release soluble silica in a different manner in cells and in the test-tube, and that some dusts liberate the silicic acid in a different and more noxious state than do others. The silica released from particles of the pathogenic siliceous dusts has special

properties, and these special properties may be due to the form in which it is released into the protoplasm in contact with the particles in the cell. *H. E. Harding.*

Diagnosis of Silicosis from Specimens Obtained at Exhumation. (Le diagnostic de la silicose sur des pièces d'exhumation.) POLICARD, A. (1947). *Pr. méd.*, **55**, 821.

The author observes that a diagnosis of silicosis may be confirmed only after death. If there is delay in performing necropsy ordinary methods may be useless and chemical analysis of the lungs may be required. It is not difficult to estimate the total silicate present; gravimetric methods being superior to colorimetric ones. The solution of the problem depends more on the interpretation of the results than on the technique. If the total silicate is less than 5% of the ash, silicosis may be excluded. Lungs may still be efficient and yet contain considerable amounts of silicate, especially in the aged. Thus, in normal persons who have not been exposed to any occupational risk up to 15% of silicate in the lung ash has been recorded. In those known to have silicosis up to 65% has been found. It is thought that a figure above 15% indicates some morbid change.

Since so many silica-containing dusts enter the lung, but are not derived from any material to which the individual is specifically exposed in his work, the interpretation of figures may present difficulty from the legal standpoint. Old scarred tuberculous foci in the lungs tend to collect around them any dusty material. If such a lung is ashed it may yield enough silicate to suggest the presence of silicosis, but in fact the greater part may have derived from the local lesion and there may be no question of any occupational hazard. Estimation of free silica is often more informative. This is more the task of the mineralogist than of the chemist. Expensive and specially designed *x*-ray plant may be required. By microanalytical methods it is possible to determine the presence of free silica even in putrified tissue, but no exact quantitative estimations are feasible. Persons who have not been exposed to a silica hazard rarely exhibit such material in their lungs. Those handling quartz invariably have free silica particles in their lungs, yet they may not be suffering from silicosis.

It is concluded that if the total silicate in the lung ash is under 10% and there are no quartz particles a diagnosis of silicosis may be rejected. If the total silicate is higher than this and many quartz particles are seen the findings suggest, but do not confirm, the diagnosis.

G. C. Pether.

Silicosis in the Glass Industry. (La silicosi nell'industria del vetro.) PERMEGGIANI, L. (1947). *Med. d. Lavoro*, **38**, 237.

Investigations were carried out in the Clinic for Industrial Diseases in Milan to determine the occupational hazards of glass workers. Among 265 cases investigated, evidence of silicosis was found in 5·7%; in workers handling refractory materials (potters, casters, and furnace makers) there was an incidence of 48%, some having associated tuberculosis. The morbid changes observed resembled those seen in potters suffering from silicosis, fibrosis being patchy but often confluent and widespread with marked pleural involvement. It would appear that Schramm is wrong in his contention that tuberculosis appears independently of silicosis in the glass industry. The development of silicosis is progresssive; out of 95 workers in the furnaces only 35 were free from disease and most of these had worked only a short time. In those affected there was clinical evidence of pulmonary lesions after about 10 years' exposure. Silicosis in glass workers has many points of similarity with the disease as observed in ceramic workers.

G. C. Pether.

Pulmonary Vascular Lesions in Silicosis and Related Pathologic Changes. GEEVER, E. F. (1947). *Amer. J. med. Sci.*, **214**, 292.

Obliterative vascular changes produced in the lungs by silicosis are the acknowledged cause of the secondary effects on the pulmonary circulation in this disease. In order to examine their precise nature 43 unselected and consecutive cases of silicosis, uncomplicated by gross pulmonary tuberculosis, were studied at necropsy, together with an equal control series. On an average, 40 pulmonary vessels of every possible calibre were sectioned from each case, and the degree of silicosis graded into discrete nodular and massive conglomerate nodular types. Microscopy, with Weigert's stain for elastic tissue, proved to be more informative than naked-eye inspection. In discrete nodular disease the small vessels within the nodules were most affected (arterioles, venules, and capillaries only), but in massive conglomerate nodular silicosis vessels of all sizes were rapidly and extensively involved. These vascular changes resulted either from direct encroachment on the vessel wall by expanding nodules or nodular masses or from infiltration by the hyperæmic cellular dust- and pigment-bearing granulation tissue along the nodule margins. Considerable variability of individual vascular resistance to these disruptive, occlusive, and infiltrative effects of silicosis was noted. Intravascular pressure changes were probably an important factor, evidenced by the finding of adventitial vasal hyperæmia and proliferation. [For the detail of the pathological lesions reference should be made to the text.]

After exclusion of all contributing degenerative cardiovascular disease, such as coronary atheroma and hypertension, over half the present series (26 out of 43 cases) were found to have right ventricular hypertrophy. Right heart failure supervened commonly in massive conglomerate nodular silicosis (11 out of 23 cases), but of the 20 cases of discrete nodular disease there was only 1 in which right-sided failure was regarded as of major ætiological importance in causing death; this was a case of bilateral pulmonary arterial thrombosis.

The lung parenchyma between the nodules underwent fibrotic changes and ischæmic necrosis; in massive conglomerate disease, anæmic cavitation occurred also. Discrete nodular disease, despite varying degrees of central necrosis, appeared to be self-limited. The death of the cells was related to a combination of factors; the age of the silicotic lesions, direct toxic action of the free silica, proliferation of fibroblasts, progressive deposition of collagen, and disruption of nourishing capillaries. However, the full role of vascular changes in stimulating pulmonary fibrosis was uncertain. Pseudo-cavities were observed in emphysematous areas and were caused by contraction of the silicotic fibrous mass and disruption of marginal alveoli, with hyperinflation following bronchiolar obliteration. The deleterious effect on the right heart of variations in pulmonary intravascular pressure which resulted from the sum of these ischæmic lesions was accounted for on the basis of Visscher's theory of decrease in the coronary vascular pressure gradient. *J. L. Lovibond.*

Pneumonoconiosis in Coal Workers in Wales. GOUGH, J. (1947). *Occup. Med.*, **4**, 86.

Simple pneumoconiosis of coal-workers is a focal disease but differs from classical silicosis. The black spots seen throughout the lungs vary from microscopic size up to 5 mm. in diameter. They may be soft or hard on palpation, depending on the amount of fibrosis, which is less dense than in typical silicosis and is rarely concentric. These areas are associated with emphysema, which is the most important feature of the disease. Radiographic reticulation is found and corresponds with these focal lesions but gives no reliable indication of the degree of associated emphysema. [The illustrations are very good.] *H. E. Harding.*

Pathogenicity of Bagasse. GERSTL, B., TAGER, M., and MARINARO, N. A. (1947). *Arch. Path.*, **44**, 343.

Suspensions of powdered bagasse proved very toxic when injected intravenously into rabbits or into the trachea of rabbits or guinea-pigs. Similar suspensions which had been autoclaved or sterilized by formaldehyde were relatively innocuous. The lesions produced by the unsterilized suspensions were scattered areas of necrosis containing polymorphonuclear leucocytes, usually foreign-body giant cells, fragments of mycelium, and a peripheral proliferation of fibroblasts. Cultures from the powdered bagasse yielded a variety of organisms. Injection of suspensions of pure cultures of these organisms showed that a type of *Aspergillus fumigatus* produced lesions closely resembling those of the original dust. In these experiments, then, the bagasse fibre appeared to act as a rather inert material, and the acute inflammatory process was due to micro-organisms, probably fungi, attached to the bagasse.

[It is not clear that these experiments throw any light on the changes occurring in the lungs of some workers who handle bagasse.] *H. E. Harding.*

Study of the Attack on and Dissolution of Aluminium Particles by Pulmonary Phagocytes. (Recherches sur la marche de l'attaque et de la dissolution des particules d'aluminium par les phagocytes pulmonaires.) POLICARD, A., and PRUVOT, E. (1947). *Bull. Histol. Tech. micr.*, **24**, 168.

White rats were made to inhale particles of aluminium during a period of increased respiration produced by rolling them in a revolving box containing the powder. The aluminium powder was that used in making metallic paint, and consisted of flat irregular plates about 5 to 8 μ thick and 5 to 25 μ long covered with a thin film of stearin. The metal was about 99·5% pure. Most of the inhaled particles stayed within bronchi, but some penetrated to the alveoli, where they were taken up by hypertrophied phagocytes. Within these cells the small plates of aluminium were slowly but steadily disintegrated during 8 to 20 weeks, until they were broken down into spherical bodies of a uniform diameter of 0·5 to 1 μ. The process of disintegration of a metallic sheet was irregular and proceeded along lines which sometimes appeared to correspond with lines of incomplete fracture. The breaking up of the metallic plates appeared to occur within the cell, and no particles were observed free in the alveoli; it was not possible, however, to demonstrate aluminium in the cell cytoplasm, which retained a normal appearance throughout.

The authors suggest that the mode of breaking of aluminium sheets may be determined by the presence of metallic impurities—iron, silicon, titanium, manganese, and vanadium—between the crystals of aluminium. *H. E. Harding.*

Nodulation with Superimposed Infection in Lungs of Foundry Grinders and Burners. Report of Four Unusual Cases. HAMLIN, L. E. (1947). *Occup. Med.*, **4**, 111.

This is a preliminary report on an experiment started in 1945, in which exposure to air-borne grinding dust for 8 to 10 months produced a faint diffuse dust pigmentation in the lungs of guinea-pigs and white rats. Histologically there were scattered inactive dust cells in the lungs without evidence of fibrosis. Some of the animals were deliberately infected with tuberculosis, but showed no acceleration of the spread of this disease as a result of inhalation of the dust.

Observation of grinders, burners, and welders in the foundry industry showed a lack of clinical symptoms and an absence of conglomerate shadows in radiographs, although nodulation was present in many. The incidence of tuberculosis was low in the industry, and when infection did appear it often progressed very slowly. Workmen seldom complained of shortness of breath, even though radiographs of their lungs showed definite, evenly distributed fine nodulation. Radiographic stippling may appear after a comparatively short period of exposure (2 to 6 years in some cases); once it appears it alters very little over the course of several years despite continued exposure to dust.

The author considers that the radiographic appearances in these men are produced by siderosis, and are not due to silicosis. In support of this view he gives details of 4 men whose radiographs had shown diffuse fine nodulation over a period of 12 to 14 years. At the first examination radiography revealed shadows in 2 of them, interpreted as due to tuberculosis, and the other 2 developed such shadows during the period of observation. All 4 men declared themselves fit and well, and their presumed tuberculous lesions either regressed or progressed very slowly during several years. The progress of the disease in these cases is taken to be inconsistent with the usual course of tuberculosis superimposed on silicosis.

[It is undoubtedly true that much of the radiographic picture in foundry workers is produced by siderosis, but, in England at least, silicosis in not uncommon in these workers.] *H. E. Harding.*

Contributions by Dr. Gardner to the Pathology of Bauxite Workers' Lung. RIDDELL, A. R. (1947). *Occup. Med.*, **4**, 56.

The author recounts 2 case-histories previously described (*J. industr. Hyg.*, 1947, **29**, 145) in which diffuse, not nodular, fibrosis was found in the lungs of workmen exposed to the fumes liberated during the fusion of bauxite in the manufacture of corundum. Chemical examination of the lungs showed a high total silica, only a small proportion of which was identifiable by *x* rays as quartz, mullite, or feldspar.

Examination of stack fumes and of settled dust in the plant showed that most of the silica was amorphous and not crystalline. Animal experiments with these two dusts were initiated by Gardner, but results in guinea-pigs are not yet available. Experiments are also proceeding on the effects on animals of mixtures of quartz or vitreous silica and aluminium oxide. A mixture of 1% of an electrically fused alumina and 99% quartz had produced no fibrosis within a month after intraperitoneal injection into guinea-pigs and intravenous injection into rabbits. *H. E. Harding.*

ENVIRONMENT

Smoke and the Public Health. MACGREGOR, A. (1947). *Med. Offr.*, **78**, 157.

Although during the last quarter of a century smoke production has diminished and its ill effects on health have lessened, smoke pollution still persists to a harmful extent in many large towns. It was estimated that 2,000,000 to 2,500,000 tons of tarry and carbonaceous matter were deposited over the country in 1945 together with 5,000,000 tons of oxides of sulphur and 500,000 tons of grit and ash. The ill effects of smoke pollution of the atmosphere may be direct, from the inhalation of chemical impurities, or indirect, from reduction in the effective sunshine. Under certain atmospheric conditions smoke assists in the destruction of life itself. The deleterious effects are most marked when fog and frost occur in a smoky town in the winter, resulting in a high concentration of grit, tar, and sulphur. For weeks afterwards this sends up the incidence of and the mortality from pneumonia and bronchitis. Figures showing the relation of fog to the mortality from respiratory diseases in some Yorkshire towns suggest that association of mist with low temperature is probably not very detrimental to health unless there is smoke pollution as well; the experience of Glasgow is that keen frost, fog, and still air occurring together are a harmful combination, mere cold without the fog not causing any increase in the fatalities from respiratory diseases.

The amount of sickness that smoke-fogs cause is much greater than can be measured by crude vital statistics, the irritant effect on the mucous membrane of the respiratory tract being especially felt by elderly people subject to bronchial catarrh who are the first to fall ill when a smoky fog arrives. Apart from its action when associated with fog, smoke accounts for some part at least of the higher mortality rates for pneumonia and bronchitis in children under 5 years of age in the Midland industrial area of Britain. Its influence in depriving towns of sunshine is demonstrated by the low sunshine average in the years 1930–2 in Bolton (975 hours), Manchester (983), and Burnley (1,000), with Blackpool's 1,368 hours. The loss of ultra-violet rays, commonly 50%, may rise to 100%. *Caryl Thomas.*

Atmospheric Carbon Monoxide in Hot Rooms in Machine Construction Plant. (In Russian.) LEITES, R. G., and KHOTSYANOV, L. K. (1947). *Gigiena*, **5**, 10.

A Government Commission studied the methods used to ventilate various metal works in which carbon monoxide escaped into the air. Figures are given in mg. per litre of air, and it is shown that some kinds of fuel and certain processes are more difficult to handle than others. During and since the war there has been a steady reduction in the carbon monoxide concentration in these works. In the severe winters workers may be tempted to reduce the ventilation, which should be controlled by the supervisory staff. *G. C. Pether.*

Improvement of the M.S.A. Electrostatic Precipitator. CLAYTON, G. D. (1947). *J. Industr. Hyg.*, **29**, 400.

An electrostatic dust sampler for use in industrial hygiene has been described by Barnes and Penney (*J. industr. Hyg.*, 1938, **20**, 3) and has been commercially developed. The present author has modified and improved this precipitator, and its operating voltage has been increased by the development of an oil-immersion coil which will provide voltages up to 13,500. Increased dependability of the electrical system has been secured, and easy changing of the vibrator points has been achieved by the use of a totally enclosed vibrator unit. A flexible head ensures greater sampling flexibility. A manometer to obtain greater accuracy in measuring flow rates and a simplified voltmeter which reliably indicates the performance of the instrument have been designed.
H. M. Vernon.

GENERAL

Studies on Age and Wastage in Industrial Populations. I. Age and Incidence. PADLEY, R. (1947). *Brit. J. soc. Med.*, **1**, 213.

The only source of information on age-distribution of diseases among the British civil population is contained in the reports of the Department of Health for Scotland, and these have been used in this analysis. The two groups studied were men and single women in the years 1936–7. The incidence of accidents in women increases with age, whereas the incidence in men tends to decline with age. The author points out that this is accounted for by increased liability to fractures among women over 45. There is not enough data available at present to determine how far this can be ascribed to differences in social habit and how far to differences in physique, but it is not due to differential fragility of bone. There is a striking difference between men and single women in relative age incidence of pulmonary tuberculosis. Among the women the distribution shows a sharp peak at the younger age groups 20 to 30; in men the distribution is spread over youth and middle life, and shows a secondary rise in the 50 to 55 age group. The author suggests that this disparity arises from industrial risks—such as silicosis among miners, to which men are alone exposed—and that if these risks were removed the male distribution might well become comparable with the female. [Clinical experience would not lead one to agree with this. This male distribution is general and does not appear to be related to particular industries, such as mining.]

The incidence of adenitis, appendicitis, diphtheria, dermatitis, measles, mumps, sore throats, scarlet fever, and "ulcers, carbuncles, boils, and abscesses" declines with advancing age; there is, however, a marked rise with age in the incidence of arteriosclerosis, asthma, bronchitis, cerebral hæmorrhage, erysipelas, hernia, myocarditis, neoplasms, phlebitis, valvular diseases of the heart, and varicose veins. Diseases showing an uncertain trend include conjunctivitis, hæmorrhoids, influenza, benign neoplasms, peptic ulcers, pneumonia, sinusitis, and tuberculosis. *K. M. A. Perry.*

PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS

FIFTIETH MEETING

The Fiftieth Meeting of the Association of Industrial Medical Officers was held at the London School of Hygiene and Tropical Medicine on Jan. 30 and 31, 1948. The President, Dr. A. J. Amor, was in the Chair. Seventy-five members attended.

Private Business

Dr. Gwynne Maitland, late Medical Superintendent, Cunard White Star Line, was elected to Honorary Membership of the Association. In proposing Dr. Gwynne Maitland, the President said that he was a Founder Member of the Association and that his great work in Industrial Medicine in the Liverpool area was well known.

Public Business

An address entitled "Coal-miners' Pneumoconiosis and Recent Developments" was given by Dr. C. M. Fletcher, Director of the Pneumoconiosis Research Unit, South Wales.

Many members took part in the subsequent discussion and the President expressed thanks to Dr. Fletcher for his particularly brilliant and interesting address. (See paper by Alice Stewart at p. 120 of this issue.)

The Association Dinner took place on the evening of Jan. 30 at the Connaught Rooms, Kingsway. The guests included Dr. Maurice Davidson, Professor E. J. King, and Dr. C. M. Fletcher. Seventy members and guests were present. Dr. Maurice Davidson spoke on "The Exercise of Judgment in Clinical Medicine" and, in a review which was both erudite and entertaining, gave sage counsel for guidance in the present difficult days of Medicine. Mr. T. E. A. Stowell referred to the successful progress which had been made with the arrangements for the International Congress on Industrial Health, which would be held in London in September, 1948.

On Saturday morning, Jan. 31, Professor E. J. King, Professor of Chemical Pathology at the British Postgraduate Medical School, spoke on "Recent Developments in the Study and Treatment of Silicosis." He said that in twentieth-century Michigan, as in the Carpathians in the seventeenth century, quarry-makers' tools were referred to as "widow-makers." The occurrence of pulmonary disease in certain industries had been recognized by Dimmerbrock in 1649, and a good description was given by Peacock in 1861. Professor King showed slides of various forms of silicotic nodulation. Haldane recognized that some types of mineral dust were not pathogenic and that they even possessed some antidotal effect. Early in the twentieth century it was thought that silicosis resulted from the sharpness of the inhaled particles exerting a mechanical effect on the lung. Gardner then showed that powdered carborundum, which consists of very sharp particles, did not produce silicosis. Gye and Purdy found in 1920 that injections of silicic acid produced a local fibrosis. There were many forms in which silica could be present in dust, for example, the crystalline form of which quartz is an example, the hydrated form, and salts of silicic acid. Kettle carried out an experiment to show that quartz particles coated with iron oxide did not produce silicosis. Professor King had found that powdered quartz was soluble to quite a surprising extent in buffered Ringer's solution. Thus, particles up to 2 microns in size were soluble to the extent of about 14 mg. per 100 c.cm. Over a period of twenty weeks no less than 10 per cent. of particles less than 1 micron in size went into solution. He suggested that the silicic acid from these particles might cause petrifaction of phagocytes. Ingested silica or silicic acid was rapidly excreted in the urine; silica injected into the blood stream was also rapidly eliminated and there was no appreciable rise in the blood silica. The solubility of fine particles varied with the type of silica, quartz having a relatively high solubility, while kaolin and shales were of low solubility, as were also sericite and mica. In general, the soluble silicas were pathogenic and the insoluble silicas produced a minimum of reaction, but there were a few exceptions, for example, some sandstones. The solubility of sericite was much increased after treatment with hydrochloric acid. Iron, aluminium, or any other metal which formed an insoluble hydroxide, would form a protective coat on silica particles and depress their solubility. For example the addition of only 1 per cent. of powdered alumina to powdered quartz reduced the solubility of the quartz from about 14 mg. per 100 c.cm. to less than 1 mg. per 100 c.cm.; powdered metallic aluminium produces the same result. In animals, the addition of aluminium to quartz dust prevented the development of silicosis.

In certain mines in Canada, the men, before they started work, were given an inhalation of aluminium dust in a specially equipped cubicle. Professor King had seen only two cases in which there was radiographic evidence of a definite reversal of the silicotic process resulting from aluminium inhalations, but there was no doubt that in some areas the workers themselves were immensely impressed with the procedures. Doubt had been cast on the value of aluminium, as a result of several deaths which had occurred in workers who inhaled fumes from bauxite furnaces in the manufacture of aluminium; these fumes contained about 60 per cent. aluminium and 40 per cent. silica. The deaths resulted from an interstitial fibrosis of the lungs. This experience had caused not only doubt, but some apprehension as to the results of aluminium therapy. There was no doubt that the inhalation of very large amounts of aluminium could be disease-producing. Workers in German aluminium stamping mills had inhaled enormous amounts of aluminium and had developed a dense interstitial fibrosis of the lungs. Professor King emphasized the value of

pre-employment medical examinations and periodic medical examinations in the elimination of silicosis, and quoted as an example the Ontario gold mines, in which silicosis, formerly very common, had been controlled by these measures. Men now entered this industry without fear of their future.

In the subsequent discussion, Dr. Keatinge said that in his experience the workers welcomed medical aid and radiographic examinations. He asked whether particles of a smaller size than 0·5 micron were of importance, as these were near the limit of resolution by the microscope. Professor King replied that particles smaller than 0·5 micron might be highly pathogenic, but there was undoubtedly a limit of particle size below which silica was not pathogenic, though this limit might be as low as about 20 Angstrom units. In reply to other questions, Professor King said that hydrochloric acid treatment did not appear to have any effect on the solubility of quartz; steatite was apparently not a dangerous dust; and although some authorities considered that certain individuals are more susceptible to silica than others, no physiological difference had yet been shown between susceptibles and non-susceptibles. Changes in the alkali reserve, or in the acid or alkaline nature of the diet, had no effect on the occurrence of silicosis in animals. No difference in the acidity of mines had been shown to be related to silicosis. The availability of radio-active isotopes had so far not been sufficient to enable much research to be undertaken in this field.

In thanking Professor King for his most interesting and instructive address, the President said that the large numbers of members attending revealed the wide interest displayed in this subject.

LONDON GROUP

At a Meeting of the London Group of the Association of Industrial Medical Officers held at The London School of Hygiene and Tropical Medicine on Wednesday, Jan. 14, 1948, Dr. H. F. Chard opened a discussion on common eye diseases in industry.

He divided his very comprehensive paper into four main sections: first, traumatic injuries, which included foreign bodies, mechanical and chemical injuries, and the effect of various dusts in the eye; secondly, toxic compounds, such as methyl alcohol, lead, etc.; thirdly, a consideration of electro-magnetic radiations, with special reference to infra-red radiations in glass bottle making, ultra-violet rays in arc welding, and ionizing rays (of which little was known) in atomic fission; and lastly, miner's nystagmus, the cause of which was due not only to bad illumination but to a psychological factor as well.

Dr. J. A. A. Mekelburg followed with a paper on the prevention of eye injuries, in which he quoted the latest available statistics to show that 5 per cent. of the total number of reportable accidents were due to eye injuries, the commonest cause of which was "foreign body."

Speaking about the regulations made under Section 49 of the Factories Act, he said that goggles were too often disregarded by the worker, and wherever possible it was preferable to have a fixed guard on the machine. For example, in dry grinding, a fixed transparent screen could be placed over the wheel, with or without an incorporated lighting unit. Since the introduction into his own engineering shop of the "Optiguard," (a specimen of which was shown) there had been no injuries from foreign bodies. In arc welding, a helmet or light-weight fibre screen with protective glass to British Standard Specification was effective, but it was worth bearing in mind that most cases of "arc-eye" had been found in welders' mates or other unprotected bystanders.

In addition to processes covered by special regulations, such as the manufacture of ærated waters, etc., there might be jobs unsuited to the average type of guard, jobs which needed careful analysis in order to determine the best means of protection.

In the discussion which followed, Mr. Joseph Minton, replying to Dr. Amor's question as to the effect of infra-red rays on the retina, said that he had seen two cases of œdema of the macula in arc welders, presumably due to infra-red rays.

Treatment of caustic soda burns was discussed, and great interest was shown in a buffered solution which was equally effective for acid or alkali burns. Dr. Chard gave the formula of this solution as follows: Monobasic potassium phosphate, 70 g.; dibasic sodium phosphate, 180 g.; water 850 c.cm. The solution is used undiluted and keeps indefinitely.

The Chairman, Dr. S. W. Fisher, thanked the speakers for their most interesting papers.

SCOTTISH GROUP

The Annual General Meeting of the Group was held on Oct. 15, 1947, at the Institute of Hygiene, Glasgow University. Dr. D. M. Watson was in the Chair. The following Office-bearers for 1947-48 were elected: Chairman, Dr. D. Gordon Robertson; Hon. Secretary and Treasurer, Dr. John Rogan. On the motion of Dr. Swanston a hearty vote of thanks was accorded to Dr. Watson for his untiring efforts on behalf of the Scottish Group during the last two years.

A Meeting of the Group was held in the Institute of Hygiene, Glasgow University, on Nov. 12, 1947, with Dr. D. Gordon Robertson in the Chair. Dr. A. Meiklejohn gave an informal talk about his experiences on a recent visit to Northern Rhodesia and South Africa. Attention was directed mainly to problems of interest to industrial medical officers. The speaker paid tribute to the excellent medical and surgical services provided by the mining companies for Europeans and Natives, and emphasized that a highly efficient industrial health service was conducted not as a separate entity, but as part of the comprehensive medical service. This service was remarkable for the high attainments of the staff and for the excellence of the hospitals and equipment.

The following briefly summarizes the main topics of the talk: The importance of aviation medicine in relation to the safety and welfare of passengers and crews; the history and development of copper mining in Northern Rhodesia, and the mining and smelting of copper ores; environmental conditions in the mines, the townships, and the native compounds; native labourers: pre-employment examination, initial training, periodical medical supervision, nutrition, accident services underground and on the surface, and welfare; prevention and control of accidents and diseases with special reference to silicosis, hookworm disease, pneumonia, dermatitis, fungus infection of the feet in change-houses, heat cramps and "dead hand" in pneumatic drilling; the work of the South African Silicosis Medical Bureau and the Witwatersrand Native Labour Association Depot at Johannesburg. Special reference was made to the unique organization for the annual mass radiography of 300,000 natives employed in the local gold-mines.

The Annual Social Meeting of the Group was held at the Grosvenor Restaurant, Glasgow, on Dec. 13, 1947.

NOTTINGHAM GROUP

A Meeting of the above Group was held at the Black Boy Hotel, Nottingham, on Jan. 22, 1948. Dr. G. E. C. Collis, Chairman, presided, and nine members and two guests were present.

The Hon. Secretary, Dr. Young, read a Minute from the last meeting of the Executive Council regarding the election of honorary members of the Association. It was unanimously decided by the Group that no further elections to honorary membership should be made without the most careful scrutiny by a small committee specially appointed for the purpose.

Following the meeting a dinner was held, and at the conclusion Dr. Collis introduced Mr. H. G. Maule who, in opening a discussion, said that serious attempts to assess the incidence of sickness and absence of industrial workers were comparatively new. Before the war only a few firms kept elaborate records. Comparison between different firms were frequently misleading, however, owing to the different methods of recording absence.

The Medical Research Council in various publications of the Industrial Health Research Board had now given a clear lead to industry (I.H.R.B. Report No. 85 : *The Recording of Sickness Absence in Industry*). If their methods were adopted, not only could an individual firm obtain accurate and useful information on the state of health of their workers, but evidence might be obtained of departments in which more than average sickness absence occurred, and such knowledge was an indispensable preliminary to effective preventive action. In addition, the pooling of such information could make a valuable contribution to our knowledge on the health of the industrial worker. The methods recommended by the I.H.R.B. should be examined and adopted by all industrial medical units, though some modification of detail might be necessary in individual firms.

The recent report of the I.H.R.B. (*The Incidence of Neurosis among Factory Workers*, I.H.R.B. Report No. 90) had shown the importance of psychological factors as contributing to total sickness absence. Unless accurate diagnosis were accompanied by accurate recording, attempts to prevent or alleviate such breakdowns were unlikely to meet with much success.

Accurate recording of accidents was a useful aid to accident prevention. A firm that was ignorant of the frequency and severity rates in different departments was less well equipped in its accident-prevention work than the firm that was supplied with this information.

Although many firms were now aware of the help that they might derive from full records of sickness and other absence, there was still a large number who regarded this as an unnecessary waste of time and paper. It was urged that those who held this view should reconsider their attitude and should make a start along the lines recommended by the Medical Research Council.

An interesting discussion followed, in which most of the members present took part.

SOUTH WALES AND WEST GROUP

A Meeting was held at the School of Preventive Medicine, Cardiff, on July 2, 1947. Thirteen members of the Association, including the Hon. Secretary and his wife, Dr. and Mrs. Pringle, were present, and it was decided to form a South Wales and West Branch. Dr. J. S. Spickett was elected as Chairman, and Dr. G. Stenlake Mundy as Hon. Secretary. Five others were elected to act, together with the Chairman and Secretary, as an Executive Committee.

On Nov. 13, 1947, a meeting of the Branch took place at Llandough Hospital near Cardiff. Unfortunately Dr. C. M. Fletcher was unable to be present. The pathology of coal-miners' pneumoconiosis was discussed by Dr. Gough. His remarks were illustrated with special slides of lung sections, and the relationship of massive fibrosis and tuberculosis was discussed. Dr. Hugh Jones dealt with lung reticulation and the frequent progress of this condition to massive shadow-formations. Clinical cases of this latter condition were shown, and both speakers pointed out the difficulty in assessing damage to the lung from *x*-ray shadows.

On Feb. 12, 1948, a visit was paid to the Mond Nickel Works, Clydach, Swansea, and an instructive afternoon was spent, special interest being shown in toxic hazards and their prevention and treatment.

A visit to the Imperial Smelting Corporation's premises at Avonmouth was undertaken on March 10. After an instructive talk on the refining of zinc, a visit was made to the works and Medical Department.

TEES-SIDE GROUP

A Meeting was held on Jan. 21, 1948, at the main offices of Messrs. I.C.I. Ltd., Billingham, and there were twelve members present to hear Mr. C. J. Thurgar, Director of the North of England Cancer Scheme, give a talk on the general problem of better diagnosis and treatment of cancer. Mr. Thurgar dealt with the difficulties encountered in organizing a department to study the problem of cancer in all its aspects. The incidence of the disease, heredity, racial differences, sites of cancer in the body and distribution geographically, as well as diagnosis and treatment were discussed. The talk was followed by a long and interesting discussion in which all those present took part and during which Mr. Thurgar answered many questions.

On Feb. 18, 1948, a Meeting was held at Billingham. Twelve members attended this meeting when Dr. W. E. Orchard, Medical Officer of Health for Darlington read a paper on tuberculosis in industry with special reference to mass radiography. During the full discussion which followed the reading of the paper Dr. Orchard replied to the many points raised.

A Meeting was held on March 17, 1948, at Billingham, and there were fifteen members present to hear Dr. A. Roberts, H.M. Regional Mines Medical Officer, give a talk on coal-mine explosions. Dr. Roberts gave an interesting account of the history of explosions in coal-mines and told how it had been discovered that an ignition of gas (CH_4) could initiate an explosion of fine coal dust, such an explosion being capable of propagation throughout the mine. For this reason, legislation had been introduced making it compulsory for all mine roadways to be treated with stone dust to reduce the combustibility of the coal dust. Dr. Roberts then dealt particularly with the explosion which occurred at the William Pit on Aug. 15, 1947, when 104 men lost their lives and showed with the aid of a mine plan how the medical evidence relating to the injuries found on the victims' bodies had helped to ascertain the site of the initial explosion and its subsequent track in the mine.